THE BEST SSDs FOR YOUR CASH
10 drives tested PG. 24

PRO WINDOWS 10 TIPS AND TRICKS
Command-line hacks PG. 38

GET STARTED WITH UBUNTU 16.04 LTS
The best Linux yet PG. 48

MAXIMUMPC

MINIMUM BS • AUGUST 2016 • www.maximumpc.com

STEP-BY-STEP GUIDE

BUILD IT!
NEXT-GEN PC

- ★ 60fps at 4K
- ★ 10-core CPU
- ★ 13TB of storage!

Intel Core i7-6950X
GEFORCE GTX
GeForce GTX 1080
DOOM

Tonight we dine in hell!
PG. 88

VR FACE-OFF
Oculus Rift vs. HTC Vive PG. 84

Future

Windows 10

CyberPowerPC recommends Windows.
One experience for everything in your life.

Gamer Infinity 8800 Pro SE

Windows 10 Home
Intel® Core™ i7-5820K Processor
GIGABYTE® X99 Chipset Mainboard
32GB DDR4 2400MHz Quad Ch. Memory
256GB SATA III SSD Boot Drive
3TB SATA II Data Hard Drive
NVIDIA® GeForce® GTX 980Ti 6GB Video Card
Zalman Gaming Headset
NZXT H440 Design by Razer Gaming Case +
600W 80+ PSU
Asetek Liquid Cooling System

Blu-ray Disc 14x Optical Drive
HD 7.1 600W
CoolerMaster®
CoolerMaster®

FROM **$1988**

Liquid Cooling **FREE**

Gamer Extreme XT

Windows 10 Home
Intel® Core™ i7-5820K Processor
GIGABYTE® X99 Chipset Mainboard
16GB DDR4 2400MHz Quad Ch. Memory
256GB SSD + 2TB SATA III 6.0 HDD 7200RPM
NVIDIA® GeForce® GTX 970 4GB Video Card
Zalman Gaming Headset
NZXT Source 340 Gaming Case +
600W 80+ PSU
Asetek Liquid Cooling System

HD 7.1 600W
CoolerMaster®
CoolerMaster®

Liquid Cooling **FREE**

FROM **$1454**

Trinity 200

Windows 10 Home
Intel® Core™ i5-6600K Processor
GIGABYTE® Z170 Chipset Mainboard with UBS 3.1
CORSAIR® 16GB DDR4 2400Mhz Dual Ch. Memory
256GB SSD + 2TB SATA-III 3.0 HDD 7200 RPM
NVIDIA® GeForce® GTX 960 4GB Video Card
Zalman Gaming Headset
Deepcool Tri Stellar Mini-ITX Gaming Case
600W 80+ PSU

FROM **$1295**

DVD 8X DVD ±RW
HD 7.1 600W
CoolerMaster®
CoolerMaster®

Order your ultimate gaming system today! **www.cyberpowerpc.com**

730 Baldwin Park Blvd., City of Industry, CA 91746

All Desktop systems come with 3 year Limited Warranty + lifetime toll free techsupport

CyberPowerPC, CyberPowerPC Logo and, Unleash The Power are trademarks of CyberPower Inc. Copyright © 2013 CyberPower. All rights reserved. All prices are subject to change without notice or obligation. Celeron, Celeron Inside, Centrino Inside, Centrino Logo, Core Inside, Intel, Intel Logo, Intel Core, Intel Inside, Intel Inside Logo, Intel Viiv, Intel vPro, Itanium, Itanium Inside, Pentium, Pentium Inside, Viiv Inside, vPro Inside, Xeon, and Xeon Inside are trademarks of Intel Corporation in the U.S. and other countries. All prices are subject to change without notice or obligation. CyberPower is not responsible for any typographical or photographic errors. NVIDIA®, nForce®, GeForce®, SLI™ are trademarks or registered trademarks of NVIDIA Corporation or its subsidiaries in the United States and other countries. CyberPower PCs use genuine Microsoft® Windows®. www.microsoft.com/piracy/howtotell

Intel Inside®. Amazing Experience Outside.

intel CORE i7 inside™

FREE LIQUID COOLING

CPUs with standard fansinks can reach core temperatures as high as 130°C, however, liquid cooling can lower that to 59°C giving you better performance and longer lifespan on your CPU.

$54.99 VALUE

Gamer Xtreme 2000

Windows 10 Home
Intel® Core™ i5-6600K Processor
GIGABYTE® Z170 Chipset Mainboard (USB 3.1)
8GB DDR4 2400MHz Dual Ch. Memory
1TB SATA III HDD 7200RPM
NVIDIA® GeForce® GTX 970 2GB Video Card
Zalman Gaming Headset
Phanteks Eclipse P400 Gaming Case + 600W PSU
Asetek Liquid Cooling System

HD 7.1 | CoolerMaster® | CoolerMaster®

Liquid Cooling FREE

FROM $1075

Gamer Xtreme 3000

Windows 10 Home
Intel® Core™ i7-6700K Processor
GIGABYTE® Z170 Chipset Mainboard (USB 3.1)
16GB DDR4 2400MHz Dual Ch. Memory
2TB SATA III 6.0 HDD 7200RPM
NVIDIA® GeForce® GTX 980 4GB Video Card
Zalman Gaming Headset
Phanteks Enthoo Pro M Gaming Case + 600W 80+ PSU
Asetek Liquid Cooling System

14x Optical Drive | HD 7.1 | CoolerMaster® | CoolerMaster®

Liquid Cooling FREE

FROM $1465

Fangbook 4 SX6-100

Windows 10 Home
Intel® Core™ i7-6700HQ Processor
Intel® HM87 Chipset
15.6" Full HD Display 1920x1080
8GB DDR3 2133MHz Memory
1TB SATA III 300 Hard Drive
NVIDIA® GeForce® GTX 960M 4GB Video Card
Full Color Programmable Keyboard
10/100/1000 Mbps Network Card
802.11 AC Wireless Network

8X DVD +RW | 250 Mins | Bluetooth 4.0 | 1x USB 3.0 1x 3.1 Type C
HDMI 1.4 | HD 30FPS Webcam | Mini-DP 1.2 | 5.29 Lbs.

15.6" HD

FROM $1099

Fangbook 4 SX7-100

Windows 10 Home
Intel® Core™ i7-6700HQ Processor
Intel® HM87 Chipset
17.3" Full HD eDP Non-Reflective 1920x1080
8GB DDR3 2133MHz Memory (16GB Max)
256GB Solid State Drive
NVIDIA® GeForce® GTX 960M 4GB Video Card
Full Color Programmable Keyboard
10/100/1000 Mbps Network Card
802.11 AC Wireless Network

8X DVD +RW | 250 Mins | Bluetooth 4.0 | 1x USB 3.0 1x 3.1 Type C
HDMI 1.4 | HD 30FPS Webcam | Mini-DP 1.2 | 5.95 Lbs.

17.3" HD

FROM $1095

CYBERPOWERPC
UNLEASH THE POWER

ORDER TODAY! 800.707.0393
www.cyberpowerpc.com

Cortana available in select markets at launch, experience my vary by device.
*External monitor must support HDMI input (If continuum-compatible accessory is not included, add: "Accessories sold seperately.") **App availability and experience varies by device and market. Office 365 subscription required for some features. †Limited to select premium phones at launch. Feature and app availability and experience may vary by market and device. Windows Hello required specialized hardware, including fingerprint reader, illuminated IR sensor or other biometric sensors.

Work easy. Play hard. Windows

Windows 10

iBUYPOWER Recommends Windows

D859

$1849

Windows 10 Home
Intel® Core™ i7-5820K Processor
ASUS X99-A/USB3.1
NVIDIA® GeForce® GTX 1080 8GB
16GB DDR4-2400 Memory
240GB SSD + 1TB 7200RPM HDD
iBUYPOWER Noctis Blue Case
Asetek 510LC Liquid Cooling
Wireless AC + Bluetooth Compatibility

Z840

$1349

Windows 10 Home
Intel® Core™ i7 6700K Processor
Gigabyte GA-Z170-HD3P Motherboard
NVIDIA® GeForce® GTX 1070 8GB
8GB DDR4-2400 Memory
240GB SSD + 1TB SATA-III HDD
24X DVDRW
Chimera Snow Case
Asetek 510LC Liquid Cooling
Wireless AC + Bluetooth Compatibility

Z807

$769

Windows 10 Home
Intel® Core™ i5-6500 Processor
Gigabyte GA-Z170-HD3P Motherboard
NVIDIA® GeForce® GTX 950 2GB
8GB DDR4-2400 Memory
120GB SSD + 1TB SATA-III HDD
24X DVDRW
Raidmax Horus Case
Asetek 510LC Liquid Cooling
Wireless AC + Bluetooth Compatibility

Work easy. Play hard. Windows

Intel, the Intel logo, Intel Core and Core Inside are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries. All content and prices are subject to change without notice or obligation.

intel CORE i7 inside

REVOLT2

$1439

Windows 10 Home
Intel® Core™ i7-6700K Processor
MSI Z170I Gaming Pro AC MB
NVIDIA® GeForce® GTX 1070 8GB
16GB DDR4-2400 Memory
240GB Intel 535 SSD
Revolt 2 RGB Case Lighting
Asetek 510LC Liquid Cooling
Wireless AC + Bluetooth Compatibility

The best Windows ever for gaming.

Gaming just got even better with Windows 10. Not only do your existing games work great, but now you can play and connect with gamers across Xbox One and Windows 10 devices. From the best casual games to a new generation of PC gaming, Windows 10 is built for the games you love. *Games and media content sold separately.

FREE LIQUID COOLING ON ALL DESKTOPS

iBUYPOWER
Order today
ibuypower.com
888-462-3899

ALL Systems are Assembled In the USA.

All iBUYPOWER Systems Come with a FREE
3 Year Warranty & Lifetime Tech Support

inside

AUGUST 2016

48
UBUNTU 16.04

24
BATTLE OF THE BRANDS
Are SSDs now all the same? Or do brands and technology matter? We put 10 drives through their paces to find out.

38
WINDOWS 10 COMMAND-LINE TRICKS
Get savvy with the Command Prompt, with our guide to making it work for you.

48
UBUNTU 16.04
As the Ubuntu release bandwagon rolls into town, we help you look past the fanfare, and discover what this latest Linux offering has in store.

QUICKSTART

12 **THE NEWS**
Google's plans for the future of tech; *Halo 5* on your PC; GeForce GTX 1070 specs; Windows 7.0 update.

18 **THE LIST**
The best *Total War* games of all time.

Intel and Nvidia join forces to power one gnarly rendering machine.

R&D

56 **AUTOPSY**
We dismantle the HTC Vive to discover the very real guts of VR.

58 **HOW TO**
Create *2048* in *Minecraft Pi;* fix Windows 10 installation problems; combine two color images together.

66 **BUILD IT**
Create a goliath workhorse.

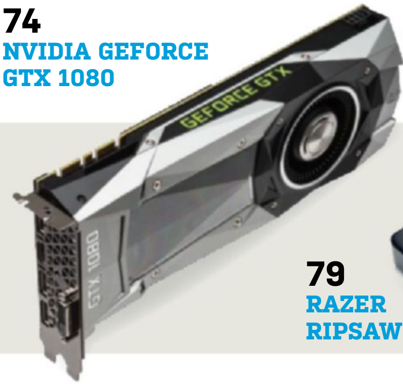
LETTERS

20 **DOCTOR**

94 **COMMENTS**

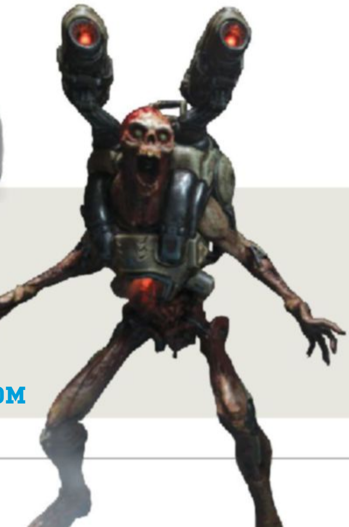
IN THE LAB

74
NVIDIA GEFORCE GTX 1080



79
RAZER RIPSAW

84 & 85
OCULUS RIFT
HTC VIVE



88
DOOM

DOMAINS | WEBSITES | CLOUD SERVERS | WEB HOSTING
SAFEST OF THE
SAFE!
100% SECURE TRANSACTION
SSL
INCLUDED

HOSTING? ONLY THE SAFEST!

1&1 provides the highest standard of protection available! Show your online visitors that their security is your top priority with:

- ✓ SSL Certificate included
- ✓ Certified data centers
- ✓ Geo-redundancy
- ✓ DDoS protection

SSL CERTIFICATE
HIGHEST SECURITY
EXCLUSIVE TO 1&1!

1 TRIAL TRY FOR 30 DAYS ★★★★★

1 MONTH FLEXIBLE PAYMENT OPTIONS ★★★★★

1 CALL SPEAK WITH AN EXPERT 24/7 ★★★★★

☎ 1 (877) 461-2631

1&1®

1and1.com

Visit www.1and1.com for full promotional offer details. 1&1 and the 1&1 logo are trademarks of 1&1 Internet, all other trademarks are the property of their respective owners. ©2016 1&1 Internet. All rights reserved.

The World's Most Advanced & Customizable

VR-Ready Systems

MILLENNIUM
CHRONOS
GENESIS

PC GAMER EDITOR'S CHOICE

MAXIMUMPC KICK ASS!

NVIDIA GEFORCE GTX

GEFORCE GTX VR READY

Online Financing Available

"ORIGIN PCs are insanely fast and backed by 24/7 expert support."

– LIRIK, Professional Streamer

ORIGIN PC VR-Ready Laptops and Desktops Feature

- No Preset Configurations
- Compatible with Your Favorite VR Equipment
- Free Lifetime Labor on Any Upgrades
- Free Lifetime 24/7 US Based Expert Support

ORIGIN
SETTLERS WANTED
EON17-SLX

ORIGINPC.COM

@originpc

ORIGIN
HIGH-PERFORMANCE PCS

© 2016 ORIGIN PC Corporation. All rights reserved. ORIGIN "O" Symbols are trademarks of ORIGIN PC Corporation.
All other trademarks are property of their respective owners.

Windows 10

Clearly the Best.

The best Windows ever for gaming.

Gaming just got even better with Windows 10. Not only do your existing games work great, but now you can play and connect with gamers across Xbox One and Windows 10 devices. From the best casual games to a new generation of PC gaming, Windows 10 is built for the games you love.

iBUYPOWER Recommends Windows

iBUYPOWER ELEMENT
$1349

Windows 10 Home
Intel i7-6700K Processor
8GB DDR4-2800 Memory
NVIDIA GTX 1070 8GB
240GB Intel 540s Series SSD
1TB 7200RPM Hard Drive
iBUYPOWER Element Case
FEATURING TEMPERED GLASS PANELS

Work easy. Play hard. Windows

iBUYPOWER
Order today
ibuypower.com
888-462-3899

All iBUYPOWER Systems Come with a FREE 3 Year Warranty & Lifetime Tech Support

ALL Systems are Assembled in the USA.

MAXIMUMPC

EDITORIAL
Editor-in-Chief: Tuan Nguyen
Executive Editor: Alan Dexter
Senior Editor: Jarred Walton
Associate Editor: Alex Campbell
Staff Writer: Zak Storey
Contributing Editor: Chris Angelini
Contributing Writers: Jonni Bidwell, Ian Evenden, Wes Fenlon, Dave James, Jeremy Laird, Chris Lloyd, Nick Peers, Mayank Sharma, Luis Villazon
Copy Editor: Katharine Davies
Editor Emeritus: Andrew Sanchez

ART
Art Editor: Fraser McDermott
Image manipulation: Simon Windsor, Gary Stuckey
Photography: Future Photo Studio, Mark Madeo

BUSINESS
Vice President, Sales: Stacy Gaines, stacy.gaines@futurenet.com
Vice President, Strategic Partnerships: Isaac Ugay, isaac.ugay@futurenet.com
East Coast Account Director: Brandie Rushing, brandie.rushing@futurenet.com
East Coast Account Director: Michael Plump, michael.plump@futurenet.com
West Coast Account Director: Austin Park, austin.park@futurenet.com
West Coast Account Director: Brandon Wong, brandon.wong@futurenet.com
West Coast Account Director: Tad Perez, tad.perez@futurenet.com
South-West Account Director: Jessica Reinert, jessica.reinert@futurenet.com
Director of Marketing: Robbie Montinola
Director, Client Services: Tracy Lam
Director, Retail Sales: Bill Shewey

PRODUCTION
Production Manager: Mark Constance
Production Controller: Vivienne Calvert
Project Manager: Clare Scott
Production Assistant: Emily Wood

FUTURE US, INC.
One Lombard Street, Suite 200, San Francisco, CA 94111
Tel: (650) 872-1642, www.futureus.com

Global Chief Revenue Officer: Charlie Speight
Vice President, Marketing & Operations: Rhoda Bueno
Vice President, Product Development: Bart Jaworski
Finance Director: Frederick Alfredo
Senior HR Generalist: Mary Mauck

SUBSCRIBER CUSTOMER SERVICE
Maximum PC Customer Care,
Future Publishing, PO Box 2024, Langhorne, PA 19047
Website: http://myfavoritemagazines.com
Tel: 1-844-779-2822 (toll free)
Lines open Monday to Friday 8 a.m. to 7 p.m.
and Sat 10 a.m. to 2 p.m. EDT
Email: contact@myfavouritemagazines.com

BACK ISSUES
Website: www.maximumpc.com/shop
Tel: 800-865-7240

REPRINTS
Future US, Inc., 4000 Shoreline Court, Suite 400,
South San Francisco, CA 94080
Website: www.futureus.com
Tel: 650-872-1642, Fax 650-872-2207

Next Issue on Sale July 26, 2016

Future
Future is an award-winning international media group and leading digital business. We reach more than 57 million international consumers a month and create world-class content and advertising solutions for passionate consumers online, on tablet & smartphone and in print.

Future plc is a public company quoted on the London Stock Exchange (symbol: FUTR).
www.futureplc.com

Chief executive Zillah Byng-Thorne
Non-executive chairman Peter Allen
Chief financial officer Penny Ladkin-Brand
Managing director, Magazines Joe McEvoy
Tel +44 (0)1225 442 244

©2016 Future US, Inc. All rights reserved. No part of this magazine may be used or reproduced without the written permission of Future US, Inc. (owner). All information provided is, as far as Future (owner) is aware, based on information correct at the time of press. Readers are advised to contact manufacturers and retailers directly with regard to products/services referred to in this magazine. We welcome reader submissions, but cannot promise that they will be published or returned to you. By submitting materials to you you agree to give Future the royalty-free, perpetual, non-exclusive right to publish and reuse your submission in any form in any and all media and to use your name and other information in connection with the submission.

Tuan
Nguyen

A WINNING COMBO FOR ULTIMATE SPEED

WELL, THAT DIDN'T TAKE LONG. SSDs may feel as though they've just arrived, but they've actually been with us for a few years now—although far fewer than the venerable hard drive. But now it seems they are approaching the end of their useful lives. Why?

The problem is the Serial ATA interface. Manufacturers have figured out that people want faster storage. Intel, in particular, relies on higher processing demands to continue justifying its CPUs. If usage and applications don't demand more power, then there won't be anything new to sell. And so, SATA is looking like it's on its way out.

Hitting a theoretical maximum of 6Gb/s, SATA hasn't improved at all. Sure, there was a brief appearance of SATA Express, but let's be realistic: it's a dud. What's in is PCI Express, and that's where SSDs are headed—new NVMe SSDs, to be exact. They're significantly faster than SATA SSDs, physically smaller, and are approaching the same capacities as SATA SSDs. Personally, I'm all in for NVMe, but I'll wait until 1TB hits mainstream. For now, it's still safe to add a SATA SSD drive to your system, but if you're in the market for a new PC, it's in your best interests to go NVMe, especially for your boot drive. Windows boot times will be much faster, as will your apps.

If that's not enough, and you're a stickler about speed, there's more you can do with Windows to speed things up, especially if you're willing to use the command line. Windows 10's command line interface (CLI) is far more powerful than in previous versions of Windows. Microsoft is taking a Linux-like approach to the CLI. You can get a lot of things done quickly by just typing instead of mouse-poking around, including running your own customized scripts. It's a powerful tool that all serious PC users should know about. We show you how to familiarize yourself and compute like a pro in the CLI this issue.

If you feel like the Windows CLI is for beginners, well, the only way to go is Ubuntu. Long-time readers will know that us folks here use both Windows and Ubuntu. Some of us even swear by it. Me, I've used Ubuntu before, but primarily for running servers. Any flavor of Linux was born as a server operating system first, even though there are mainstream desktop flavors.

Ubuntu has been a crowd favorite. It gets the most updates, has the widest range of application support, and supports the widest range of hardware. If you want rock-solid stability and support, though, you'll want Ubuntu LTS—long-term support. Ubuntu LTS won't have the most recent gizmos, but it does have thoroughly tested drivers, software, and modules. Ubuntu LTS stays on a specific Linux kernel version for longer than usual. If you're brave enough to try, you can even install it without a graphical user interface. Command line that!

While you're at it, install Ubuntu on to that new NVMe SSD. Talk about speed!

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

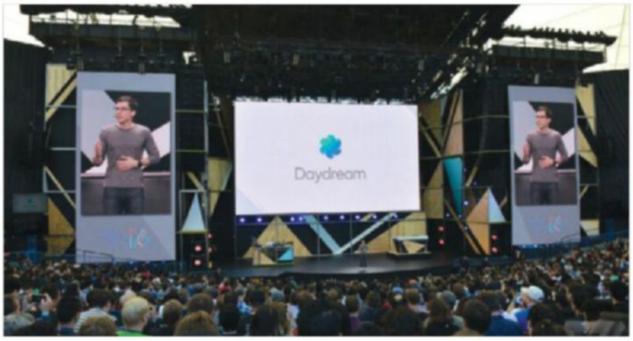
Google's Plans for the Future of Tech

Google I/O 2016 showcases this year's big releases

EVERY YEAR since 2008, Google has put on a big software developers' conference in San Francisco, where the best of its forthcoming releases are revealed. Each year, it seems to get better, and better, as Google gets more ambitious and capable. This year was no exception.

The most exciting news was Daydream, Google's new foray into VR, and much more serious than last year's Cardboard VR. Daydream puts you inside your Android device; there's a small "pebble" controller used to navigate and control the action. VR versions of many major apps, notably YouTube, are ready. You'll need compatible hardware, with a fast screen, and accurate sensors, though.

Nobody has done mobile consumer VR properly yet; it's been too cumbersome, unresponsive, blurry, pricey, or compromised in some other way. Google promises Daydream will be comfortable, light, responsive, and affordable. Hardware and software partners are lined up, and Daydream hardware and software is due in the fall. There was no news on Google's own non-Cardboard hardware, though, just sketches of a reference design. Daydream comes coupled with a new VR-friendly version of Android, so far known only as Android N.



Want to live inside your smartphone? Google is about to make a serious attempt at decent mobile VR later this year.

Google Now is transforming into Google Assistant. It's clever enough for you to modify questions with follow-up statements, or ask further questions referencing previous ones. "We want people to have an ongoing two-way dialog," said CEO Sundar Pichai. It is more chat bot than a simple voice-activated search. After a query on a film, for example, you can follow with "Is it any good?" and it brings up appropriate reviews. We're getting closer to machines you can talk to, rather than dictate to.

> Google promises Daydream will be comfortable, light, responsive, and affordable.

This ties in neatly with Google Home, a voice-activated Wi-Fi speaker, giving you access to your assistant, music library, and all your connected devices. Given a suitably wired-up home, you'll be able to set the date in your calendar, order the flowers, dim the lights, and pick the mood music with your voice.

The Allo and Duo apps bring machine learning to everyday connectivity. Allo is a kind of text bot. It learns from your responses, and then offers a selection. Instead of predictive text, we have predictive whole messages. It works with images, too. Duo is a one-to-one video-calling app with similar machine learning built-in. Both are due this summer.

Google Wear gets its first major update since the 2014 launch. Version 2.0 connects independently, via Bluetooth, Wi-Fi, or cellular. No need to have a partnered phone in your jacket. A new custom version of Android is designed with a round watch face in mind, and has handwriting recognition.

On the Chromebook front, you'll soon be able to download Android apps via Google Play. It looks as if Android and Chrome are quietly getting into step—rumors have been flying that the two systems will become one next year. Chromebooks outsold Macs for the first time in the first quarter of this year.

Many of these new ideas draw on Google's core strength: 17 years of search data to mine—it can customize and predict what you want. This is where rivals struggle; Siri is good, but she hasn't all the background data to work out context.

Love it or suspect it, Google has grown from a simple search engine to become a massive company, with huge resources and seriously big ideas. Increasingly, when we want to know how we are going to interact with technology this year, we tend to ask Google. **–CL**

TRION 150
OCZ

OCZ STORAGE SOLUTIONS
POWERED BY TOSHIBA NAND
A TOSHIBA GROUP COMPANY

BREAK OUT OF THE ORDINARY

GET INTO A SUPERIOR COMPUTING EXPERIENCE WITH TRION 150 SOLID STATE DRIVES

- Up to 550 MB/s
- Up to 90,000 IOPS
- Premium Toshiba TLC NAND flash
- SSD GURU Management Software
- Available up to 960GB

If you're tired of your hard drive's snail-like speed and want a performance upgrade that won't break the bank, look to a company who has your back – OCZ. The newest Trion 150 SSD series not only delivers a superior computing experience, but provides the ultimate balance of value and quality. Leveraging premium Toshiba TLC NAND flash as well as Toshiba controller technology, the Trion 150 features low-power optimization, a worry-free customer service experience and warranty, and endless relief from system lag. Don't fall victim to never-ending PC upgrades that put **serious** dents in your wallet. Break out of the ordinary and embrace extraordinary.

OCZ
STORAGE SOLUTIONS
A Toshiba Group Company
ocz.com
OCZ SHIELDPLUS
WARRANTY

HALO 5 ON YOUR PC

Forge only, but you do get to play

THE DEVELOPER of *Halo 5: Guardians*, 343 Industries, is to release the game's Forge map-building toolset for the PC and Windows 10. You'll be able to design and play your own levels, then test multiplayer games with people on your Friends list. There is no single-player campaign, online Matchmaking, or cross-platform support, but you'll have access to all of *Halo 5's* Arena multiplayer maps.

Moving to the PC has brought support for multiple resolutions, including 4K, while editing is easier and more precise, thanks to the benefit of mouse and keyboard control. You can also use the mouse and keyboard in game, which will undoubtedly please many old-school gamers. It has also been built from the ground up to use DirectX 12.

Rumors that this release is a prelude to a full PC version of *Halo 5* have been rebuffed by 343 Industries. The next PC release is still officially *Halo Wars 2*, due this fall. 343 did blog that "Windows 10 remains an important focus for the *Halo* franchise." A bit of a mixed message there. *Halo* is a big part of the Xbox One brand; perhaps porting it directly on to a PC, complete with all the security issues that would entail, is asking a bit much, for now. But pushing Windows 10 gaming cred has to be part of the equation.

Forge—Halo 5: Guardians Edition for Windows 10, to give it its full and rather clumsy title, will be available as a free download later this year. It's not everything that fans have been after, but you do get to play the latest *Halo* on your PC, the first time since 2007's *Halo 2* port. Suit up, ladies. **–CL**

GEFORCE GTX 1070 SPECS

A BETTER DEAL?

NVIDIA'S GEFORCE GTX 1080 is a monstrous bit of gear (review, pg. 74). It is also expensive, at $700 for the Founders Edition. Its little brother, the GTX 1070, is about to arrive at a more affordable $450 ($380 for the non-Founders Edition). It carries a cut-down version of the same 16nm core, 1,920 CUDA cores against 2,560, and slightly slower clocks of 1,506MHz and 1,683MHz boost, against 1,607 and 1,733MHz. The 8GB memory is slightly slower GDDR5, and five of the 20 streaming multiprocessor cores are disabled. TFLOPS is down from nine to 6.46, still out-gunning the 5.6 TFLOPS of the GTX Titan X. As before, all this is achieved with low power consumption: 150W TDP. We still have the same banging 16nm Pascal GP104, so we can expect performance above anything at this price, and readily capable of VR. **–CL**

WINDOWS 7.0 UPDATE UPDATE

Every update in one go

Please do not power off or unplug your machine
Installing update 11 of 208

Windows 7 Professional

MICROSOFT HAS NOT RELEASED a Service Pack for Windows 7.0 since Service Pack 1 back in 2011. This becomes a proper annoyance if you ever want to reinstall Windows 7.0, because there is a lot of updating to do—years of it. The process becomes a cycle of booting, downloading, installing, and rebooting.

Microsoft has finally come up with Windows 7 SP1 convenience roll-up, which is, in effect, a new Service Pack, but Microsoft isn't calling it that—however, it is what you want: all the security and non-security updates rolled into one package. It's not part of Windows Update either; you need to manually find and download it. It's hosted at Microsoft's Update Catalog. If you plan to go there, you'll need Internet Explorer to do it, naturally. The site currently uses ActiveX—support for other browsers comes later this year. **–CL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

UBER DRIVERS

Uber is testing its first driverless taxi in Pittsburgh. It'll mix with ordinary traffic, but it still carries a driver to monitor things, and step in if required.

LONGER TWEETS

The limit is still going to be 140 characters, but images and URLs will no longer count toward the total.

RETURN OF THE FLIP PHONE

Do you miss the Motorola Razr? It looks as if there will be a new updated version of the classic slim flip phone from Lenovo later this year.

TRAGEDIES

CHINESE ASTROTURFING

A Harvard University report says Chinese government agents make 488 million social media posts a year, to deflect criticism of the state.

TESLA CRASHES ITSELF

Tesla updated its software to stop its cars driving out of a space the wrong way, after one of its cars crashed.

SNEAKY UPDATE

Microsoft has changed the way it asks Win 7.0 and 8.1 users to upgrade; unless you know to click on the X, it's easy to agree to an unwanted update.

Dave James

TECH TALK

GDDR5X vs. HBM Gen2: It's No Contest

NVIDIA'S NEW Titan X-beating Pascal graphics cards aren't rocking the advanced stacked memory shenanigans of AMD's top cards, or even its own pro-level Tesla GPUs. So, with the second generation of HBM hitting soon, that's got to be a disadvantage for the green team's new 1000 series GPUs, right? Well, really it's no contest.

At the start of April, Nvidia unveiled its latest Tesla graphics processing behemoth, based on the brand new 16nm Pascal architecture. And there was much rejoicing. We were shown a 15.3-billion-transistor beast, with a huge number of stream processors, and vast swathes of second-generation high-bandwidth memory (HBM), with unprecedented levels of memory bandwidth.

Fast-forward to May, and Jen-Hsun was back on stage showing off the very first consumer versions of Nvidia's much-vaunted Pascal GPU architecture. And, despite some stunning performance claims, they're very much second-tier GPUs compared with the GP100 chip at the heart of the top-tier Teslas.

That's not a huge surprise, given that Nvidia has always liked to keep something back to fill the ultra-enthusiast segment. But what is maybe a little more surprising is that the GTX 1080 has eschewed the HBM we know Pascal is capable of supporting—less we forget, AMD's last generation GPUs supported it.

While you might be sad you're not getting a 4,096-bit memory interface or 720GB/s bandwidth in your GTX 1080, the use of GDDR5X memory in conjunction with the GP104 silicon makes sense, and is one of the reasons we'll see a card that's 25 percent faster than a Titan X, but for 40 percent less cash. GDDR5X is a new standard in graphics memory, but is still built on the same foundations as GDDR5. That's important, because it makes it the perfect match for a second-tier GPU set to power multiple cards throughout Nvidia's 1000-series stack. It means Nvidia's chip designers didn't need to find some convoluted way to ensure the GP104 GPU was cross-compatible with the more complex HBM memory as well as the older GDDR5 standard.

> The new GTX 1080 has eschewed the HBM we know Pascal is capable of.

GDDR5X introduces the holy trinity of higher performance, greater capacity, and improved efficiency, but as well as that, because it follows the traditional GDDR5 design, one GPU is capable of supporting both the new and older standards. Hence the GTX 1080 comes with GDDR5X, and the slightly cut-down GP104 of the GTX 1070 rolls with old-school GDDR5.

It's also far cheaper for Nvidia to implement a 256-bit memory interface with GDDR5X, knowing it can rock higher density 10Gb/s memory chips, rather than the more complex HBM standard. And it still gets to post impressive memory bandwidth scores without the cost of HBM or a 384 or 512-bit bus.

GTX 1080
GEFORCE GTX

The GTX 1080 has the performance of the Titan X, if not the bandwidth.

But none of this means GDDR5X is going toe-to-toe with HBM; it genuinely is no contest. The second-gen HBM standard will offer bandwidth of 1TB/s, while even the top GDDR5X spec's 14Gb/s modules can only offer 448GB/s. But HBM is expensive and only going to be used on the top cards for the foreseeable future. Lower down the stack, Nvidia gets to offer significantly improved capacities and bandwidth without a huge bump in pricing.

HBM and GDDR5X, then, are likely to remain in two distinct camps of graphics card, with neither liable to impinge on the other's turf. Well, until Polaris tips up, maybe....

Dave James has been building and writing about PCs and their components for the last two decades.

YOUR PERSONAL GUIDE TO THE UNIVERSE

DISCOVER SCIENCE SERIES

148 PACKED PAGES

Wonders of the Universe

The secrets of the cosmos revealed

ALIEN HUNTING
EARTH'S EVIL TWIN
A STAR IS BORN
WEIRD SCIENCE
ROBOT ASTRONAUTS

OUT NOW!

DELIVERED DIRECT TO YOUR DOOR

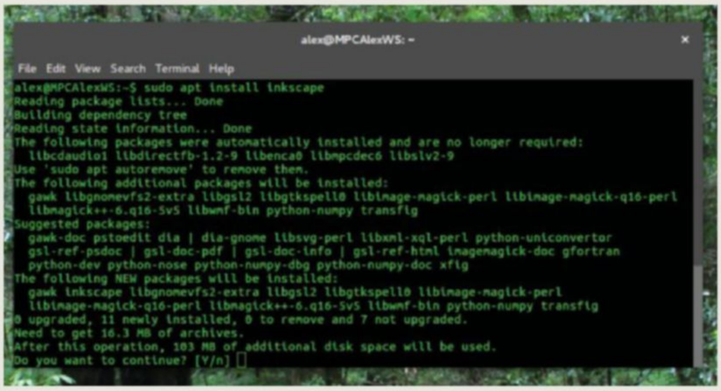
Order online at **www.myfavouritemagazines.com**
or find us in your nearest supermarket, newsagent or bookstore!

Alex Campbell

OPEN SOURCE

Package Managers Are an Awesome Mess

ONE OF THE FIRST THINGS you usually do after you boot into a fresh Windows installation is go looking for third-party software, such as Firefox, Chrome, Steam, VLC, and maybe an office suite. That means opening up Microsoft Edge (or Internet Explorer), navigating to the site you want, and clicking about a dozen times per software installation.



```
alex@MPCAlexWS:~$ sudo apt install inkscape
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libcdaudio1 libdirectfb-1.2-9 libenca0 libmpcdec6 libslv2-9
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  gawk libgnomevfs2-extra libgsl2 libgtkspell0 libimage-magick-perl libimage-magick-q16-perl
  libmagick++-6.q16-5v5 libwmf-bin python-numpy transfig
Suggested packages:
  gawk-doc pstoedit dia | dia-gnome libsvg-perl libxml-xql-perl python-uniconvertor
  gsl-ref-psdoc | gsl-doc-pdf | gsl-doc-info | gsl-ref-html imagemagick-doc gfortran
  python-dev python-nose python-numpy-dbg python-numpy-doc xfig
The following NEW packages will be installed:
  gawk inkscape libgnomevfs2-extra libgsl2 libgtkspell0 libimage-magick-perl
  libimage-magick-q16-perl libmagick++-6.q16-5v5 libwmf-bin python-numpy transfig
0 upgraded, 11 newly installed, 0 to remove and 7 not upgraded.
Need to get 16.3 MB of archives.
After this operation, 103 MB of additional disk space will be used.
Do you want to continue? [Y/n]
```

Ubuntu's Apt in action on the command line.

The first-boot Linux experience is different, and is one of the best things about the modern Linux desktop. First of all, many Linux desktops come pre-installed with the likes of Firefox and LibreOffice, but you still need to get the other things, such as Chrome (well, Chromium) and VLC. Doing this usually takes just one or two entries on the command line. In Ubuntu, this looks something like "sudo apt update" and "sudo apt install chromium vlc." The package manager Apt looks for the software, looks up its dependencies, fetches them, and then asks whether you want to install all of those packages.

You then relax as the system does its magic. It's awesome, but there's a problem with the Linux package manager ecosystem, and it's the fact that there's an ecosystem of package managers at all.

There's a slew of package systems to choose from: Debian, Ubuntu, and derivatives (such as Linux Mint) use Apt; Fedora and Red Hat use YUM; OpenSUSE uses ZYpp, which is compatible with YUM; Slackware has Pkgtools; Arch uses Pacman; and Gentoo uses Portage. And that's just the big names. Every distro can always fall back to .tar.gz tarballs and install software from source, as well.

This is a big problem, because when a developer wants to release software for Linux, it has to choose how to package it. As it stands, developers tend to distribute .rpm files for Fedora, and .deb files for Ubuntu most of the time. Everyone else gets a tarball. And that blows.

> “When you think about it, there aren't that many people who ditch their distribution's default package manager.

And it's not the developers' fault. Developers spend most of their time writing software. That takes time and energy—they don't want to exhaust that effort making pretty packages for every distro. That task falls to package maintainers.

While we're here, let's give a big hand to package maintainers. Seriously. These folks do a lot of grunt work for distributions. These poor souls donate their precious time to package the latest versions of their chosen software project of choice for the distribution they use. And that's not the end of their responsibility. They have to answer to the community when installs fail, or when a script calls for the wrong dependency. It's a thankless job that only exists because of package system fragmentation.

Like it or not, it's likely we'll be stuck with this system for a long time. Package managers are one of the core elements that differentiate distributions from one another.

People may install Fedora and use something besides Gnome, while others may ditch Unity when they install Ubuntu. But when you think about it, there aren't that many people who ditch their distribution's default package manager.

They really are some of the best and worst parts about Linux.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

THE BEST TOTAL WAR GAMES OF ALL TIME

MEDIEVAL II: TOTAL WAR Essentially *Rome: Total War* reskinned, this was a smidge more balanced.

TOTAL WAR: SHOGUN 2 This remake was just a little too basic and a little too simple for our tastes.

NAPOLEON: TOTAL WAR Cannons, guns, steam ships, not really Napoleonic warfare—what's not to love?

TOTAL WAR: ROME II Buggy, but if it weren't for *Rome II*, we wouldn't have the perfection of *Attila*.

SHOGUN: TOTAL WAR *Shogun* was the revolutionary real-time strategy title that started it all.

ROME: TOTAL WAR Balance was nigh on invisible, but this game catapulted the series to stardom.

TOTAL WAR: ATTILA Divine—the pinnacle of CA's excellence, with a challenging in-depth campaign.

Windows 10

AMD

AMD RADEON GRAPHICS AMD FX AMD A SERIES

CyberPowerPC recommends Windows.
One experience for everything in your life.

Unlock the world's first 8-core desktop CPU.
Oh wait, we already did.
Get 8-Cores in your system.

FREE LIQUID COOLING

CPUs with standard fansinks can reach core temperatures as high as 130°C, however, liquid cooling can lower that to 59°C giving you better performance and longer lifespan on your CPU.

$54.99
VALUE

Gamer Scorpius 8000

Windows 10 Home
AMD-FX 6300 Processor
GIGABYTE® GA970A-D3 AMD 970A USB 3.0 & SATA III
CORSAIR® 8GB DDR3 1600Mhz Dual Ch. Memory
2TB SATA III HDD 7200RPM 32MB Cache
AMD Radeon™ R9 380 2GB DirectX 12
Zalman Gaming Headset
NZXT Source 340 Orange
Asetek Liquid Cooling System

Liquid Cooling FREE

FROM **$769**

8X DVD +RW · HD 7.1 · CoolerMaster® · CoolerMaster®

Gamer Scorpius 9000

Windows 10 Home
AMD-FX 9590 Processor
GIGABYTE® AMD FX990 USB 3.0 & SATA III
CORSAIR® 16GB DDR3 1600Mhz Dual Ch. Memory
256GB SSD + 2TB SATA III DATA HDD
AMD Radeon™ R9 390X 8GB DirectX 12
Zalman Gaming Headset
Thermaltake Core V31 + 600W 80+ PSU
Asetek Liquid Cooling System

Liquid Cooling FREE

FROM **$1345**

14x Optical Drive · HD 7.1 · CoolerMaster® · CoolerMaster®

Syber Vapor E

Windows 10 Home
AMD Athlon X4 840
AMD A88 Chipset MB USB 3.0 and SATA III
CORSAIR® 4GB DDR3 1600 Mhz Dual Ch. Memory
256GB SATA III SSD Boot Drive
AMD Radeon™ R7 360 2GB Video
Logitech Wireless Game Controller
Syber Mini-ITX Gaming Cases + 350W PSU

FROM **$499**

HD 7.1 · Bluetooth 4.0 · 1x USB 3.0 · Mini Keyboard®

Gamer Dragon

Windows 10 Home
AMD-FX 8320 Processor
GIGABYTE® 970 USB 3.0 & SATA III
CORSAIR® 8GB DDR3 1600Mhz Dual Channel Memory
1TB SATA III HDD 7200RPM 64MB Cache
AMD Radeon™ R9 380 4GB DirectX 12
Raidmax Viper II + 600W 80+ PSU
Zalman Gaming Headset
Asetek Liquid Cooling System

Liquid Cooling FREE

FROM **$779**

24X DVD +RW · HD 7.1 · CoolerMaster® · CoolerMaster®

730 Baldwin Park Blvd., City of Industry, CA 91746
All Desktop systems come with 3 year Limited Warranty + lifetime toll free techsupport

CyberPowerPC, CyberPowerPC Logo and, Unleash The Power are trademarks of CyberPower Inc. Copyright © 2013 CyberPower. All rights reserved. All prices are subject to change without notice or obligation. AMD, the AMD Arrow logo, AMD PhenomTM II, AMD PhenomTM, ATI RadeonTM Graphics, 790 Series, and combinations thereof are trademarks of Advanced Micro Devices, Inc. NVIDIA®, nForce®, GeForce®, SLITM are trademarks or registered trademarks of NVIDIA Corporation or its subsidiaries in the United States and other countries.
Cortana available in select markets at launch, experience my vary by device.

*External monitor must support HDMI input (If continuum-compatible accessory is not included, add: "Accessories sold seperately.") **App availability and experience varies by device and market. Office 365 subscription required for some features. ‡Limited to select premium phones at launch. Feature and app availability and experience may vary by market and device. Windows Hello required specialized hardware, including fingerprint reader, illuminated IR sensor or other biometric sensors.

CYBERPOWERPC
UNLEASH THE POWER

ORDER TODAY! **800.707.0393**
www.cyberpowerpc.com

Work easy. Play hard. Windows

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> High-End Audio
> G-Sync Options
> Storage Troubles

Audio Upgrade

Hey, Doc. First off, I have to say I absolutely love the magazine. It's full of interesting articles and teeming with knowledge. It's an invaluable resource for me, even if my wallet would prefer that I didn't read it every month. I especially dug the April issue, in which you guys reviewed audiophile-class DACs and headsets. It pushed me over the edge to finally upgrade my current setup. I've been using Astro A40s since my *Halo 3* days. The headset served me well, but I'm in search of better sound quality, especially for music. Do you think you could help with this upgrade?

I love the Astro MixAmp's functionality, as far as allowing me to have both my XB1 and PC hooked up. So, I'm looking for a DAC that can replace its connectivity, and swap out the 16-bit depth/48kHz sampling rate for higher-fidelity 24-bit depth/192kHz sampling.

As far as cups, I had my eye on the OPPO PM-3s, and the Audio Technica ATH-M50 and ATH-AG1X. All of them earn pretty solid reviews. My budget (with headphones) is around $700 to start, and I'm a sucker for aesthetics. Also, I'm not too worried about an integrated microphone, because I'm looking for a standalone. Do you have a prescription for me? **–Dillion T**

Affordable audiophile-class quality? It would be hard to go wrong with HiFiMAN's HE400S.

THE DOCTOR RESPONDS: Thanks for your question. To help answer it, the Doc enlisted the help of *Maximum PC* editor-in-chief, Tuan Nguyen.

"You piqued my interest, Dillon. I've tried all of the high-end headsets, and then some. For around $700, there are a few options available to you, depending on how you like the tone of your audio. I'll give you three possibilities. The first is HiFiMAN's HE400S, which doesn't cost even half of what you're prepared to spend, but offers audio quality that beats cans selling for more than $1,000. It's very well balanced and is open-circumaural, which essentially guarantees an excellent sound stage. Stepping up, I'd recommend going with OPPO's PM-2 instead of the PM-3. It has the same planar-magnetic driver as the company's flagship PM-1, without the luxurious packaging. Its sound is on the warmer side, with crisp highs, along with good low-end slam. And it never sounds muddy—the bass is tight! If you prefer clarity over all else, another fine option for slightly crisper highs is Sennheiser's HD 700. It's not quite as piercing as the HD 800 and offers better bass. My go-to DAC? OPPO's HA-1. I recommend you take your dose immediately."

We're Watching

First of all, thanks for the work you do at *Maximum PC*. With your help, I built a killer PC that makes all of my friends jealous whenever they come over.

So, my question is, are you spying on me? Back in December, I was looking to buy some SSDs and put them in RAID 10, and your next issue had everything I needed to know about solid-state storage and RAID. Later in January, I was wondering what graphics card should replace my aging GeForce GTX 750 Ti. I went to my local book store, grabbed a copy of my favorite magazine, and there in the reviews section was Zotac's GTX 980 Ti AMP! Extreme. One month later, I started looking at displays to pair with my new high-end graphics card. I ran back to the book store and opened up the February issue of *Maximum PC* to find a whole section dedicated to monitors. Fast-forward two months, and I was wondering how to improve my audio subsystem. In April, most of *Maximum PC* was focused on audio. Again, problem solved. Would it surprise anyone to hear that the following month I took apart and cleaned my PC, wondering how to get the most out of my fans, and found the answer in *Maximum PC*? If you guys are spying on me, then thank you! **–Brandon Chesser**

THE DOCTOR RESPONDS: The *Maximum PC* team is, in fact, keeping an eye on you, Brandon. Don't stop thinking about your next upgrade—our editorial calendar depends on it! Seriously, though, on behalf of everyone here, thank you for your patronage.

Making More of G-Sync

Greetings, Doc. I'm the proud owner of a new Acer Predator

↘ submit your questions to: doctor@maximumpc.com

XB271HU monitor, and I have to say I'm very happy with it. This display has just about every feature I've been wanting, including G-Sync.

As my PC is configured now, I have two GeForce GTX 980 Tis in SLI. When I open the Nvidia Control Panel and click the "Set up G-Sync" option, I have the "Enable G-Sync" box checked. Just beneath it, "Enable G-Sync for full screen mode" is also selected. On the Global Settings tab from within "Manage 3D settings," I have the "Monitor Technology" option set to "G-Sync." Way down near the bottom of that same menu is another option for "Vertical Sync," which is set to "On." Correct me if I'm wrong, but I thought G-Sync was a better option for my monitor, as I have it paired with an Nvidia card. Shouldn't "Vertical sync" in Nvidia's Control Panel be set to "Off?" To make the G-Sync settings even more confusing (to me, at least), I found that I can turn vertical sync off for individual programs and games in the Program Settings tab, under "Manage 3D settings," as well. Then there are the options you see in the games themselves, which let you toggle VSync on or off.

So, my question is, what adaptive sync settings should I be using to get the most out of my new display? Thanks in advance for your assistance.

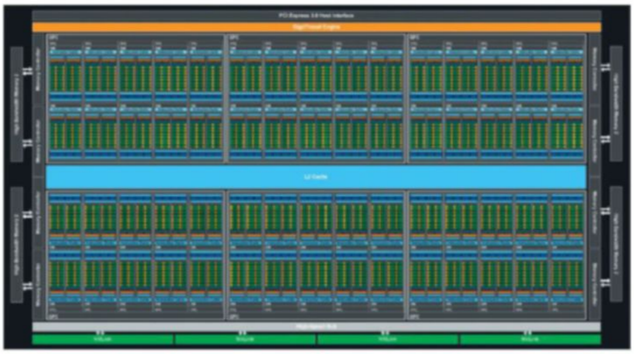
–Joseph Machorro

THE DOCTOR RESPONDS: The behavior of Nvidia's driver changed last year when the company added G-Sync support in windowed mode. Previously, G-Sync only worked in games running full-screen, and you'd set that "Vertical Sync" option to "G-Sync." Now, as you noticed, the only available options are "On" or "Off."

Under "Set up G-Sync" you have the "Enable G-Sync" box checked—that's good. If you ever play games in a window on your desktop, say, to tab out and watch a boss strategy on YouTube or look up a piece of loot post-victory, change the radio button under the box to "Enable G-Sync for windowed and full screen mode."

Now, back in the "Manage 3D settings" menu, with "Monitor Technology" set to "G-Sync," the "Vertical Sync" field controls your monitor's behavior outside of its variable refresh range. The VRR of your XB271HU is 30Hz to 165Hz. So, let's say you're playing a game that peaks at 200fps—between 165 and 200fps, you need to define a VSync behavior, because G-Sync isn't engaged. The Doc recommends keeping the option set to "Off." Above 165Hz, tearing shouldn't be a problem, and you'll avoid the input lag that is associated with VSync.

The Programs Settings tab enables you to override the Global Settings. In some games, you might find it preferable to use the Acer display's ultra-low motion blur feature (accessible in that "Monitor Technology" drop-down) instead of G-Sync, particularly if your graphics subsystem is capable of very high performance. An override enables you to configure this per-title, so that you aren't forced to tweak your settings between games.



Next-gen graphics cards are on the way. We already know that Nvidia's Pascal-based GP100 is a 15.3 billion-transistor beast.

Storage Issues

What's up, Doc? I upgraded my mom's mechanical hard drive to an SSD, and now it's constantly maxed out at 100 percent activity and locking up the machine (a refurbished Gateway DX4375G-UW20 with an AMD A6-5200 quad-core processor and 6GB of RAM). I upgraded the OS to Windows 10 Home. Its SSD is a 120GB PNY CS1311. As part of my troubleshooting regimen, I disabled the Windows Search and SuperFetch services, along with increasing the paging file size.

Her mechanical disk used to run all of the time, too, and I was hoping that upgrading it to an SSD would resolve the issue. It hasn't, though. Now it actually seems worse. Instead of just being slow, it locks up. I cannot tell from the Task Manager's Performance tab what could be causing the issue aside from a Windows process. I'm not sure what else to try—do you think you could help?

–Steve Ruegsegger

THE DOCTOR RESPONDS: Although the Doc hasn't seen this particular issue in his lab, it's clear from a quick search that many others have experienced it. In fact, it's easy to get lost in the sea of theories and possible solutions.

However, one Reddit thread is full of Windows 10 users who saw their disk usage drop from 100 percent after changing one of the operating system's behaviors. It's a shot in the dark, but click the Windows icon, select "Settings," and click the System icon. From the left-hand menu, choose "Notifications & actions," then turn "Show me tips about Windows" off. If that doesn't work, you can experiment with turning off other notifications, as well.

Graphics Upgrade

Hello, Doctor. I built my current PC about two years ago, and it recently met its match in *CoD: Advanced Warfare,* with the detail settings maxed out.

Acer's XB271HU sports a refresh range of 30–165Hz, so no worries about tearing or input lag.

My motherboard is an Asus Z87M-PLUS, and the CPU is a Core i7-4770K at stock clock rates. I currently have a GeForce GTX 760 graphics card, 16GB of RAM, and a mix of hard drives and SSDs.

Eventually, I'd like to run three monitors, though currently I use a 24-inch screen at 1920x1080. To that end, I'd like to upgrade my GPU. Would it be more economical to add another GTX 760 in SLI, or buy one of the 900-series cards? How would SLI perform compared to a GTX 970 or better? And can I run three monitors in SLI? I have lots of questions because reading your fine publication generates more every day.

–Bill Keenan

THE DOCTOR RESPONDS: Without a doubt, Bill, that GTX 760 is bottlenecking your performance, even at 1920x1080. Nvidia has just divulged the details of its Pascal architecture, and our GeForce GTX 1080 review can be found on page 74. We'll know more about the other cards in the family soon as well. Rather than adding a second GPU in SLI, or getting a 900-series card, wait to see what Pascal (or AMD's Polaris architecture) offers. Next-gen manufacturing technologies are expected to do wonders for efficiency, meaning you'll get more performance for less power. And, yes, any upcoming card can be expected to include enough outputs for three monitors.

SAGER
NOTEBOOK COMPUTERS

Call Us Toll-free: 800.669.1624 Go Online: SAGERNOTEBOOK.COM

A GAME CHANGER!

TAKE YOUR GAMING TO THE NEXT LEVEL.

NP9870-S Notebook
$2,999

After $200 Instant Savings

- 6th Generation Intel® Core™ i7-6700K Processor (8MB Smart Cache, 4.0GHz)
- Windows® 10 Home 64-bit Edition
- 17.3" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- 30 days No Dead Pixel Guaranteed Insurance
- 8GB DDR5 NVIDIA® GeForce™ GTX 980 GPU
- Optional Dual NVIDIA® GeForce™ GTX 970M or GTX 980M GPU with SLI™ Technology
  - 24GB DDR4-2133MHz Memory
  - 256GB Samsung 950 PRO M.2 PCIe NVMe SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives or 2 M.2 PCIe SSD Drives capable
- Hardware Raid 0,1 Function capable
- Full sized Keyboard with color LED backlight
- Killer™ DoubleShot-X3™ Pro (2X Killer E2400 LAN + Killer Dual Band Wireless-AC 1535) with Smart Teaming
- USB 3.1 / Thunderbolt Gen3 Combo Port
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Foster speakers & a sub-woofer tuned by SoundBlaster
- Sound Blaster® X-Fi™ MB5 Sound System

intel®
CORE™ i7
inside™

Intel Inside®
Extraordinary Performance Outside.

Dealer/VAR, Government and Corporate pricing are available. Please call for details.

Sager One Year Limited Warranty Policy: 30-Day Money-Back Guarantee. If the equipment does not work as promised, or if you are not fully satisfied, we will issue a full refund upon the return of all original equipment. 1-Year Parts and Labor Limited Warranty. Lifetime Toll-Free Technical Support. Sager One Year Limited Warranty, Two Year Limited Warranty and Three Year Limited Warranty Policy Applies to End Users in the United States of America only. Extended Warranty Available: Check out this comprehensive package of service/support. Sager Corporate Offices 18005 Cortney Court, City of Industry, California 91748 Tel: 626.964.8682, Fax: 626.964.2381 Hours: Monday-Friday 7:30a.m. - 6p.m.(PST) American Express, VISA, MasterCard & Discover Credit Cards Accepted - No Surcharge. Cashiers Checks Welcomed. ©2016 by Midern Computer, Inc. All rights reserved. Ultrabook, Celeron, Celeron Inside, Core Inside, Intel, Intel Logo, Intel Atom, Intel Atom Inside, Intel Core, Intel Inside, Intel Inside Logo, Intel vPro, Itanium, Itanium Inside, Pentium, Pentium Inside, vPro Inside, Xeon, Xeon Phi, and Xeon Inside are trademarks of Intel Corporation in the U.S. and/or other countries. All company and/or product names mentioned herein are trademarks and/or registered trademarks of their respective companies. Prices and specifications are subject to change without notice. Opened software and shipping charges are non-refundable. 30-Day money back guarantee does not include freight or shipping and handling charge. *Free UPS Ground Shipping valid to contiguous US order only.

NP9778-S Notebook
$2,399

After $150 Instant Savings

- 6th Generation Intel® Core™ i7-6700K Processor (8MB Smart Cache, 4.0GHz)
- Windows® 10 Home 64-bit Edition
- 17.3" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- 30 days No Dead Pixel Guaranteed Insurance
- 8GB DDR5 NVIDIA® GeForce™ GTX 980M GPU
- Opt. NVIDIA® Quadro® M3000M / M5000M GPU with model NP9775
- 16GB Dual Channel DDR4-2133MHz Memory
- 256GB Samsung 950 PRO M.2 PCIe NVMe SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives or 2 M.2 PCIe SSD Drives capable
- Hardware Raid 0,1 Function capable
- Full sized Keyboard with color LED backlight
- Killer™ DoubleShot™ Pro (Killer E2400 LAN + Killer Dual Band Wireless-AC 1535) with Smart Teaming
- USB 3.1 / Thunderbolt Gen3 Combo Port
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo Hi-Fi speakers and a sub-woofer
- Sound Blaster® X-Fi™ MB5 Sound System

NP9758 Notebook
$1,999

FREE UPS GROUND SHIPPING*

- 6th Generation Intel® Core™ i7-6700 Processor (8MB Smart Cache, 3.40GHz)
- Windows® 10 Home 64-bit Edition
- 15.6" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- Opt. 15.6" 4K QFHD Matte Display with G-SYNC
- 6GB DDR5 NVIDIA® GeForce™ GTX 970M GPU
- Optional NVIDIA® GeForce™ GTX 980M GPU
- 8GB DDR4-2133MHz Memory
- 500GB Samsung 850 EVO M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives or 2 M.2 PCIe SSD Drives capable
- Hardware Raid 0,1 Function capable
- Full sized Keyboard with color LED backlight
- Killer™ DoubleShot™ Pro (Killer E2400 LAN + Killer Dual Band Wireless-AC 1535) with Smart Teaming
- USB 3.1 / Thunderbolt Gen3 Combo Port
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo Hi-Fi speakers
- Sound Blaster® X-Fi™ MB5 Sound System

NP8658-S Notebook
$1,799

After $150 Instant Savings

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Opt. Unlocked Intel® Core™ i7-6820HK Processor
- Windows® 10 Home 64-bit Edition
- 15.6" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- Opt. 15.6" 4K QFHD Matte Display with G-SYNC
- 30 days No Dead Pixel Guaranteed Insurance
- 8GB DDR5 NVIDIA® GeForce™ GTX 980M GPU
- 16GB Dual Channel DDR4-2133MHz Memory
- 250GB Samsung 850 EVO M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives or 1 M.2 PCIe SSD Drive capable
- Hardware Raid 0,1 Function capable with SATA Interface
- Full sized Keyboard with white-LED backlight
- Intel® Dual Band Wireless-AC 8260 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 1.13 inch thin

NP8678 Notebook
$1,699

After $50 Instant Savings

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Opt. Unlocked Intel® Core™ i7-6820HK Processor
- Windows® 10 Home 64-bit Edition
- 17.3" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- 8GB DDR5 NVIDIA® GeForce™ GTX 980M GPU
- 8GB DDR4-2133MHz Memory
- 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives Capable with Raid 0, 1 Function
- Full sized Keyboard with white-LED backlight
- Intel® Dual Band Wireless-AC 8260 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers and a subwoofer
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 1.18 inch thin

NP8677-S Notebook
$1,499

After $200 Instant Savings

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Windows® 10 Home 64-bit Edition
- 17.3" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- 30 days No Dead Pixel Guaranteed Insurance
- 3GB DDR5 NVIDIA® GeForce™ GTX 970M GPU
- 16GB Dual Channel DDR4-2400MHz Memory
- 250GB Samsung 850 EVO M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives Capable with Raid 0, 1 Function
- Full sized Keyboard with white-LED backlight
- Killer™ Dual Band Wireless-AC 1535 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers and a sub-woofer
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 1.18 inch thin

NP8657-S Notebook
$1,399

After $150 Instant Savings

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Windows® 10 Home 64-bit Edition
- 15.6" Full HD Matte Display (1920x1080) (NVIDIA® G-SYNC Technology optional)
- 3GB DDR5 NVIDIA® GeForce™ GTX 970M GPU
- 16GB Dual Channel DDR4-2133MHz Memory
- 250GB Samsung 850 EVO M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives Capable with Raid 0,1 Function
- Full sized Keyboard with white-LED backlight
- Intel® Dual Band Wireless-AC 8260 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 0.98 inch thin

NP8640 Notebook
$1,299

FREE UPS GROUND SHIPPING*

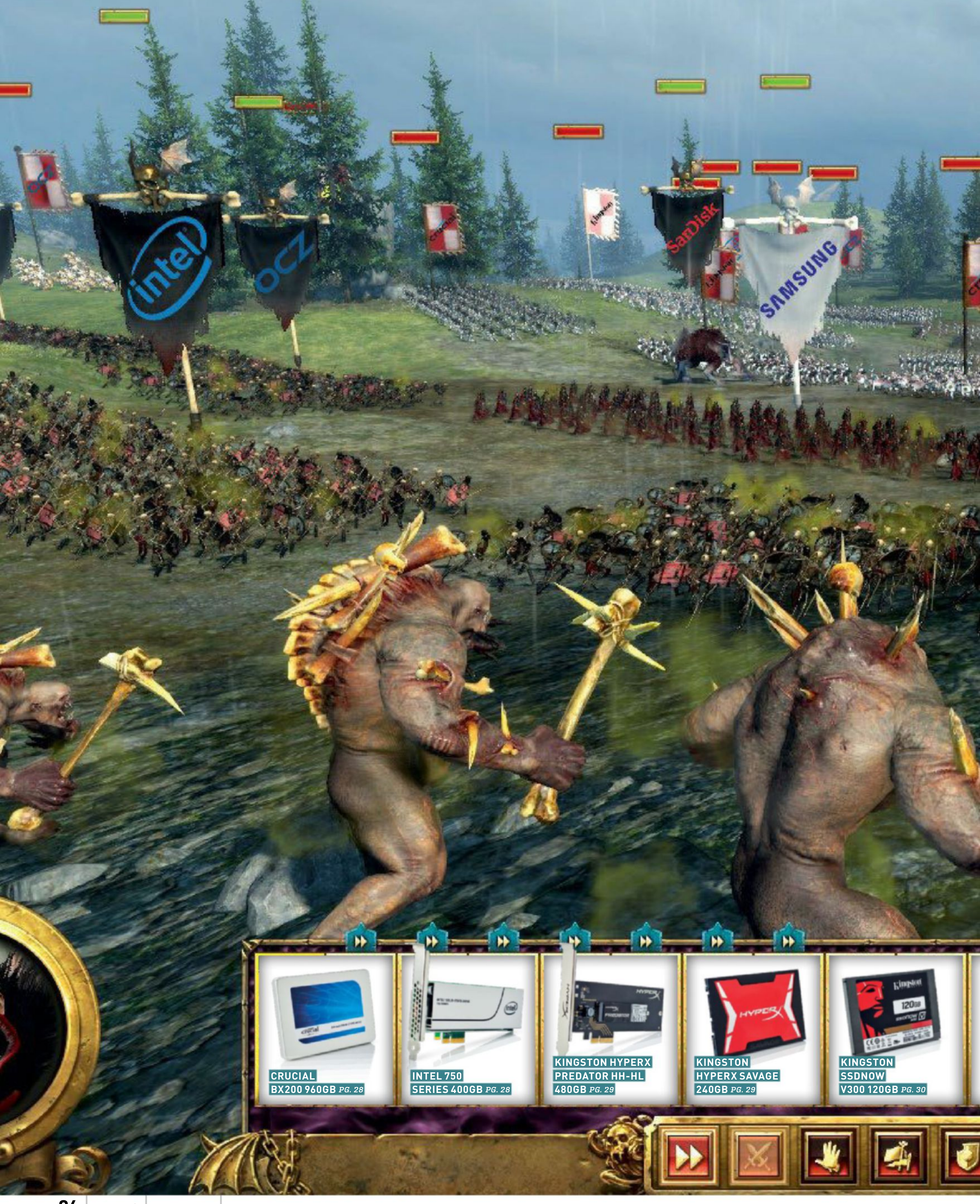
- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Windows® 10 Home 64-bit Edition
- 14" Full HD IPS Matte Display (1920x1080)
- 3GB DDR5 NVIDIA® GeForce™ GTX 970M GPU with Optimus™ Technology
- 8GB DDR4-2133MHz Memory
- 1TB 5400RPM Hard Drive
- 1 Hard Drive + 1 M.2 SSD Drive or M.2 PCIe SSD Drive capable
- A4 sized Keyboard with white-LED backlight
- Intel® Dual Band Wireless-AC 3165 + Bluetooth
- Built-in 2.0M FHD Camera
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 0.99 inch thin

NP7256 Notebook
$899

After $100 Instant Savings

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Windows® 10 Home 64-bit Edition
- 15.6" Full HD IPS Matte Display (1920x1080)
- Also available in 17.3" Display with model NP7276
- 2GB DDR5 NVIDIA® GeForce™ GTX 960M GPU with Optimus™ Technology
- 8GB DDR4-2133MHz Memory
- 1TB 7200RPM Hard Drive
- 8X DVD±R/RW/4X +DL Super Multi Drive
- 1 Hard Drive + 1 M.2 SATA SSD Drive or M.2 PCIe SSD Drive capable
- Full sized Keyboard with white-LED backlight
- Intel® Dual Band Wireless-AC 3165 + Bluetooth
- USB 3.1 support
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers

Customize and Instant Pricing at: SAGERNOTEBOOK.COM


intel
OCZ
SanDisk
SAMSUNG
Kingston
Crucial
CRUCIAL BX200 960GB PG. 28
INTEL 750 SERIES 400GB PG. 28
KINGSTON HYPERX PREDATOR HH-HL 480GB PG. 29
KINGSTON HYPERX SAVAGE 240GB PG. 29
KINGSTON SSDNOW V300 120GB PG. 30

BATTLE OF THE BRANDS

Are SSDs now all the same? Or do brands and technology matter? *Jeremy Laird* investigates

BRANDS ARE A BIG DEAL. Lifestyle, aspiration, perceived value—all this and more is intimately associated with brands. And when it comes to SSDs, if there is one thing you want to know, it's the brand. It's far from all you need to know, but in our experience, SSDs in a given class tend to align by brand. As you'll see, this month's roundup of 10 SSDs from across the price spectrum—representing many of the best known brands, and including a wide range of technologies—largely confirms this.

Of course, there are plenty of things beyond brand that matter. In fact, there's probably more choice and innovation in the solid-state market now than ever before. That starts with the immediate conundrum any SSD buyer must face in the choice between a standard SATA drive and something based on one of the hot new PCI Express storage interfaces.

Are you happy with the 500MB/s peak bandwidth and outdated AHCI protocol limitations that come with SATA drives? Or are you ready to make the jump to a new drive based on the lightning-fast PCI Express interface? If you like the idea of the newer technology, what about motherboard and OS compatibility? And does the new PCI Express generation actually make your PC feel faster? Or is anything beyond a decent SATA drive a case of diminishing returns?

Then there's the cost versus capacity question, and does capacity-enhancing tech like TLC NAND and 3D NAND come at the cost of performance or longevity?

OCZ TRION 100 960GB *PG. 30*

SAMSUNG 850 EVO 500GB *PG. 31*

SAMSUNG 850 PRO 2TB *PG. 31*

SAMSUNG 950 PRO M.2 512GB *PG. 32*

SANDISK SSD PLUS 240GB *PG. 32*

Intel's beastly 750 Series PCI Express SSD cranks out GB/s of bandwidth.

Even the best brands, sometimes get it wrong.

Puny but powerful: Are M.2 drives, such as the Samsung 950, the future?

Is a SATA drive all you actually need for a general-purpose or gaming PC?

WHAT'S A BRAND WORTH TO YOU? With Hollywood celebs such as Gwyneth Paltrow and Reese Witherspoon pitching their very beings as brands, and asking the world to buy into everything from cocktail napkins to so-called curated lifestyles, you might think the whole notion of branding and brands has descended into self-parody. And we won't argue.

However, when it comes to PC hardware, and solid-state drives in particular, brands still matter. In fact, they matter more than you might expect, given that the components inside SSDs are pretty generic. In that context, asking why SSD quality should align with branding is thoroughly legitimate.

Allow us to explain. There's a ton of SSD brands, but few of them make the critical hardware that goes into SSDs themselves; stuff such as flash memory and controller chipsets. For the most part, SSD makers buy that stuff off the shelf, from a small set of suppliers. So, you might expect most SSDs to be pretty similar once you get past—yup, you guessed it—the branding. But they're not, and the reason is that there's more to it than just throwing a few parts together. That's where brands make the difference. Just for starters, even using off-the-shelf parts, you can still cut corners or fluff things up to make the numbers look sexy.

Obvious kludges include things such as not making optimal use of the memory channels, using cheap cache memory to enable hot-looking but unsustainable peak speeds, or skimping on the over-provisioning of spare memory. Cheapskate moves like these can compromise peak performance and longevity.

The other important areas involve validation, optimization, and fine-tuning. Take some generic memory, add a third-

The Great Compatibility Conundrum

So, you like the look of one of those hot new SSDs based on the PCI Express interface, and offering that newfangled NVMe storage control protocol, but will they even work in your PC? Now, that is a critical question.

The good news is that OS support is widespread. Windows 8.1 onward supports NVMe natively. For Windows 7, there's a hotfix available from Microsoft. Instead, the most likely barrier is your motherboard. For starters, your board may lack the latest storage interfaces. We're talking about M.2 and U.2 ports.

Of course, there are pure PCI Express SSDs and PCI Express adapter cards that enable you to physically plug an M.2 or U.2 drive into almost any PC—but that doesn't necessarily mean you will be able to boot from it, or that your motherboard will be able to support the NVMe protocol for optimal performance.

For instance, without an NVMe-aware BIOS, your motherboard usually won't be able to boot from an NVMe SSD. The answer, then, goes something like this. If your motherboard has either an M.2 slot or U.2 connectors, you'll know you are good to go. If it lacks those features, you need to refer to the manufacturer's website. Search for BIOS updates and look for one that adds NVMe support. The older your board, the less likely it is that a compatible update has been created.

party controller chipset. You can even use the firmware supplied by the chipset maker to manage the whole shebang. The result would be a fully functional drive and competitive-looking numbers on paper, but it wouldn't necessarily be a great drive.

That's because, when it comes to more nuanced metrics—such as performance consistency over time and, indeed, overall longevity of a drive—the devil really is in the detail. It takes proper investment in engineering and development to produce a really consistent and polished SSD. In practice, that means that even some of the really big SSD brands might take a controller chipset and its firmware from a third party. But they polish it and hone it into something worthy of their brand.

In that sense, the shared third-party origins of many SSDs are irrelevant. The value is in the development and validation, which is when the $64,000 question becomes that of the identity of those "better" brands. At this point, we'll wheel out the usual journalistic caveats. First, not every drive from the best SSD brands is a zinger. Samsung has had some well-publicized issues with its Evo family of drives and their TLC flash memory, for instance, even if the company has usually taken pro-active measures to fix problems. Similarly, several of Intel's early SSDs were prone to pretty catastrophic bork.

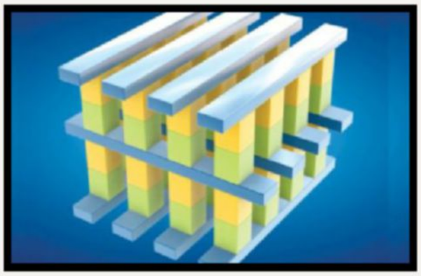
Secondly, all of this does not mean that drives from brands outside the safe list are automatically or even usually garbage. Not even close. It's more a case of the best brands more consistently producing drives worthy of your PC. Indeed, some independent testing has shown that most SSDs are capable of surviving hundreds of terrabytes of sustained data writes beyond their claimed endurance levels. And those "better" brands, in no particular order, are Plextor, Intel, Samsung, Sandisk, and Crucial. If that's what you might call the top tier, brands including Mushkin, Corsair, Toshiba, Kingston, OCZ, Western Digital, and others form a second tier that's either that little bit less proven or has one or two black marks to its name.

If branding is big issue number one this month, the other major question is the choice between an old-school SATA drive and one of the newfangled drives based on the PCI Express interface—M.2 or U.2, for instance. Even the most cursory perusal of our benchmark results demonstrates that PCIe SSDs offer massively more peak performance: SATA drives top out at around 550MB/s; the fastest PCIe drives benchmarked this month rock in at over 2.5GB/s. Yup, five times faster.

Without question, there are real-world benefits to that kind of performance. If you regularly shunt large quantities of data around—maybe if you're big on raw video editing—peak throughput like that is a huge benefit. It doesn't hurt for things such as game level loads, either. However, when it comes to the daily grind of computing, you could argue that today's SSDs, with their circa 500MB/s performance, are sufficient in terms of peak throughput. Instead, it's random access that makes more difference and would most benefit from improvement in existing SATA drives.

The reason for that is twofold. Part of it comes down to the limitations of the NAND memory used in all existing SSDs. NAND memory isn't addressable at the bit level, and that can make working with little itty bitty reads and writes hard work. The other problem is that the IDE and AHCI control protocols used by the SATA interface predate the solid-state revolution, and aren't optimized for SSDs.

The solution to NAND's shortcomings might be an all-new memory technology from Intel and Micron (see boxout on the right). We'll have to wait a little while for that. However, the new NVMe protocol is here today in the latest PCI Express SSDs, and probably the single most intriguing aspect of our benchmarks this month involves random access performance. Just how much faster are those hot new NVMe-powered SSDs? Time to find out.



Flash Memory Times a Thousand

It's pitched as the first major breakthrough in memory tech for 25 years, but just how big a deal is Intel and Micron's 3D XPoint joint venture? It's a non-volatile memory tech, like the flash memory in an SSD, but it's not a souped-up version of anything existing—it's completely new.

The claims are pretty staggering. 3D XPoint is claimed to be up to 1,000 times faster, 10 times denser, and 1,000 times more robust than existing flash memory. The real-world numbers are unlikely to fully deliver, but when Intel demoed 3D XPoint at IDF, the result was seven times faster IOPs performance than a conventional flash memory comparison drive. A big jump.

So, how does it work? Instead of having memory cells composed of gates, in which electrons are trapped, 3D XPoint is resistance-based. Each cell stores its bit of data by changing the conductive resistance of the cell material. This means transistors aren't required, making for smaller cells and higher density.

What's more, the memory cells are addressable at the individual bit level. That's a huge advantage over NAND memory, where whole blocks of memory, typically 16KB, have to be programmed to save just one bit of data. With NAND, that limitation leads to the need for read-modify-write shenanigans, and can dramatically slow things down. XPoint promises the kind of performance we currently associate with volatile memory, like RAM.

When will it arrive? Intel says it plans to ramp up production for retail versions at the end of 2016, so watch this space. But if XPoint is even half as good as Intel claims, it's going to be stunning.

Crucial BX200 960GB

Big, cheap, a little bit borked

CRUCIAL IS THE RETAIL arm of the monster memory manufacturing outfit that is Micron. It's Micron, along with its partner Intel, that is promising to totally revolutionize solid-state memory, with its new 3D XPoint technology toward the end of this year. Put simply, Micron is undoubtedly a major player in solid-state memory. Via its Crucial brand, it has consistently produced great SSDs.

We therefore had high hopes for its latest budget drive, the BX200. Priced at $260 for this near-1TB model, the BX200 offers epic bang for your buck. Under the hood, there's an updated version of the Silicon Motion SSD controller Crucial used in the old BX100, along with Micron's latest 16nm TLC NAND memory.

Peak performance is up slightly on the BX100. However, a significant drop in claimed 4K read performance versus the BX100—down to 66K IOPS from 90K IOPS—is the first indication that the BX200 may not actually represent flawless progress.

In terms of benchmark performance, it puts in a decent enough showing in most of the synthetic tests. Sequential reads and writes are up around 450MB/s or more, regardless of what benchmark tool you prefer to use. It looks pretty solid for 4K random access performance, too, edging out the budget opposition, including the SanDisk SSD PLUS and Kingston SSDNow.

However, we couldn't help notice a major drop-off in performance when transferring our test files during the setup process, and that was a harbinger of badness to come. In our 30GB real-world file copy benchmark, the BX200 was dog slow, and required nearly 2.5 times as long to complete the test as the budget SanDisk drive.

As for the reason why, the explanation at least in part involves the sluggish program and erase times that come with the transition to triple-level NAND from the two-level NAND used in the BX100. But, whatever the reason, there's no avoiding the disappointing conclusion: Crucial's budget SSDs used to be no-brainers—not any more.

VERDICT **6**

Crucial BX200 960GB

⊕ **THE MOUNTAIN** Seriously big; competitively priced; reassuring brand.

⊖ **THE HOUND** Disappointing sustained data transfers; SATA is so last year.

$260, www.crucial.com

Intel 750 Series 400GB

An awesome alternative to M.2

SIZE MATTERS. At least, it does with some PC components. Check out the beasts of the graphics card market for proof. But SSDs? Not so much. In fact, it's a measure of the insane innovation in solid-state storage that the two hottest competitors of our benchmarkathon are also the biggest and littlest of this test, physically speaking.

So, the fact that this Intel 750 Series SSD is far larger than Samsung's diminutive 950 Pro reflects a difference in interface, not necessarily capacity or performance. Where the Samsung is an M.2 drive, this Intel is pure PCI Express. Of course, you could say it boils down to much the same quad-lane PCI Express capabilities in both.

That's not the only similarity. Just like the Samsung drive, this Intel SSD is one of the very few that can be said to be the vision of just one company. Intel makes the memory, the controller, and the firmware.

As for specs, there's a certain amount of tit for tat. Peak read performance is similar for both drives, at 2.5GB/s for Samsung and 2.2GB/s for this 400GB version of the Intel 750. But Samsung claims a 50 percent performance advantage for writes, with Intel rating the 750 Series 400GB model at 900MB/s. On the other hand, Intel makes bolder claims for 4K random access performance, with 430K read IOPS and 230K writes. Game on.

In synthetic tests, such as CrystalMark and ATTO, the drives line up much as the claims would have you expect. The Samsung 950 has a marked edge in sequential writes, while Intel parries that with a lead in 4K random writes. If there is a surprise, it's the Intel 750's disappointing 4K random read performance. At 40MB/s, it's not as good as the best of the SATA drives. That's disappointing, given that the new NVMe protocol is supposed to revolutionize performance for this kind of workload.

It's also disappointing because random access performance is responsible for making a PC subjectively feel speedy with day-to-day tasks. Arguably, then, for most people, most of the time, the benefits of these brave new PCI Express drives may not be all that dramatic.

VERDICT **8**

Intel 750 Series 400GB

⊕ **LOTTERY WIN** Seriously quick sequentials; PCI Express card brings wide compatibility.

⊖ **PAYDAY LOAN** Disappointing 4K reads; not exactly cheap.

$299, www.intel.com

Kingston HyperX Predator HH-HL 480GB

It's PCIe, so where's the NVMe?

THINGS ARE CHANGING FAST in SSD land. For proof, look no further than the Kingston HyperX Predator 480GB. In many ways, it's right at the bleeding edge of storage technology. And yet, it's not quite the full next-gen package.

For starters, this version combines an M.2 board with a half-height PCI Express adapter board, making it physically compatible with almost any motherboard. It also cranks out peak performance numbers well beyond any conventional SATA SSD. But it's missing a vital next-gen ingredient—instead of using the hot, new NVMe protocol, it makes do with AHCI, as seen in SATA drives.

In other words, the HyperX Predator is a stepping stone rather than a full leap to a next-gen drive. One obvious impact involves 4K random access performance, with 117K read IOPS and 78K write IOPS. That would be good for a SATA SSD, but well off the pace compared to some PCIe drives that support the new NVMe protocol. Whoops.

That said, omitting support for NVMe does bring one theoretical advantage. It should broaden support in terms of motherboards that can boot from this drive; you won't need a mobo that supports NVMe. In practice, it's difficult to be categorical. Testing the HyperX Predator with every possible system configuration is impossible. Reports from the field suggest that mileage varies significantly, so we advise careful research before assuming you'll be able to boot into Windows with this SSD.

If you can, you'll probably be pretty pleased with the results. It's not quite as quick as the best NVMe drives, but its sequential transfer performance still beats a conventional SATA drive with a very big stick. As expected, 4K random access performance looks more like a very good SATA drive than a next-gen PCI Express drive.

As a compromise for systems that don't support the NVMe protocol, and lack an M.2 slot, the Predator is super appealing. We just wish we could be more unequivocal about motherboard compatibility in terms of bootability.

VERDICT

7

Kingston HyperX Predator HH-HL 480GB

⊞ **ARNOLD SCHWARZENEGGER** M.2 plus PCIe adapter gives you every option; nifty sequential performance.

⊟ **STEVEN SEAGAL** No NVMe support; 4K performance is nothing special; compatibility doubts.

$300, www.kingston.com

Kingston HyperX Savage 240GB

A bundle of SATA-powered fun

HIGH PERFORMANCE for middling money. It's a simple enough proposition Kingston is offering with the HyperX Savage 240GB. But is it true?

As reviewed, the HyperX Savage is a little more complicated. This is the upgrade bundle, with a recommended price of about 10 bucks more than the stand-alone drive; though, at retail, the stand-alone drive is usually a fair bit cheaper. For extra cash, you get a 2.5-inch to 3.5-inch adapter, a SATA cable, Acronis True Image HD, a USB 3.0 enclosure, and even a screwdriver: all you need to smooth the transition of your existing installation on to a new drive. And it's awesome value for money.

What about the drive itself? Inside, you'll find a relatively new controller chip from Phison: the PS3110-S10. It's pretty high-spec, with four processing cores and eight memory channels. Kingston has also gone for conventional MLC, rather than TLC, NAND memory. That bodes well for both longevity and performance, even if the three-year warranty is nothing special.

The claimed performance looks solid all around for a SATA SSD, and it's worth noting that the Phison controller doesn't suffer the same slowdowns with incompressible data that blights the SandForce controller in Kingston's own SSDNow V300. In our benchmarks, the HyperX Savage looks nifty, too. Compared to the mega-money Samsung 850 Pro 2TB drive, there's remarkably little in it by most metrics. In terms of the real-world computing experience delivered by both drives, we suspect you'd be very hard pressed to tell the two apart. Do you really care, for instance, if your file copying takes 2 minutes and 26 seconds, instead of 2 minutes and 16 seconds? Doubtful.

All of which means your choice and the value proposition comes down to longevity. The Samsung drive packs a massive 10-year warranty versus the three-year cover provided by Kingston. That's not just a bit of a gap, it's a chasm. But if you upgrade your SSDs at least every three years, it's also academic. Factor in the Upgrade Kit goodies, and the HyperX Savage looks better value yet.

VERDICT

8

Kingston HyperX Savage 240G

⊞ **MMMM, UPGRADES** Great all-around package; solid performance.

⊟ **IT'S NO NEO** Slightly stingy warranty; how long will it last?

$120, www.kingston.com

Kingston SSDNow V300 120GB

SandForce tech soldiers on…

THERE WAS A TIME when the SandForce SF-2281 SSD controller stalked the land like some kind of murderous zombie immortal, annihilating all in its path. As an SSD maker, if your drives didn't have a SandForce controller, they'd soon be dead in the market. Resistance was futile.

As it happens, SandForce's controllers leapt to prominence about the same time as the so-called "white walkers" from a certain fantasy TV series entered the public imagination. Coincidence? Whatever, that was then—now, we'd turn this already strained metaphor around and ask whether winter is coming for the Kingston SSDNow V300's competition. Or whether this SandForce-powered SSD is just a dumb zombie drive that needs to be put down. Over to Samwell Tarly for the technical analysis.

On paper, the V300 seems to have something of a pulse. This drive rocks in at a modest 120GB, but at least sports Toshiba 19nm MLC NAND memory, rather than the lowest of the low TLC memory, with all the reliability concerns that can suggest. Peak claimed speeds of 450MB/s in both directions, and 55,000 write IOPS, look OK, too.

Initially, the benchmarks don't look too shabby, either. Fire up something like the ATTO Disk benchmark, and you get numbers north of 500MB/s for both reads and writes. Nice. The 4K random access numbers are tolerable, too.

Unfortunately, things don't look too clever thereafter. Traditionally, the SandForce controller's performance has looked a lot less clever when handling incompressible data, and so it is with the V300. AS SSD and CrystalMark reveal sequential speeds of around 130MB/s—mediocre.

Worst of all is the real-world data copying test. We had a feeling this was going to be ugly when setting the drive up. In the Windows dialog box, it was obvious that the V300's initially speedy performance drops off rapidly. The upshot is a result of 6 minutes and 47 seconds on the file copy test—last among these 10 SSDs. It's also nearly three times slower than what we'd class as a decent SATA drive. Ouch. Even Melisandre couldn't make this drive look lively. Someone grab the dragon glass and do the honors.

VERDICT
6

Kingston SSDNow V300 120GB

⊞ **MOTHER OF DRAGONS** So cheap, they're almost giving it away…

⊟ **WINTER IS COMING** …but you still might not want it.

$42, www.kingston.com

OCZ Trion 100 960GB

So much SSD, so little money…

WE LIKE A LITTLE VARIETY. So it was a thumbs up from us when Toshiba picked up the smoking remains after memory specialist OCZ slammed into the bankruptcy wall. OCZ had cooked up some technically intriguing SSDs over the years—though some were a little short on polish.

What OCZ needed was some corporate-style attention to detail, the sort of quality control and validation that big companies do best. Companies like Toshiba. The result is the OCZ Trion 100, reviewed here in 960GB format.

Much of the component mix has moved to Toshiba technology. That starts with 19nm Toshiba TLC NAND memory. That's novel for OCZ, so it ruled out the use of OCZ's Barefoot controller chip and, in turn, prompted the change up to a Toshiba TC58 controller, which, rumor has it, is derived from Phison S10, as also seen in the Kingston HyperX Savage. The Kingston drive, of course, uses faster Toshiba MLC, rather than TLC, memory.

But, as we said, a little variety is very welcome, so the opportunity for a direct comparison between MLC and TLC memory, with ostensibly similar controller technology, is intriguing. Unfortunately, the outcome for OCZ confirms the tardy reputation of TLC memory.

It looks reasonable, if slower than the Kingston drive, in pretty much all the synthetic benchmarks. Whether it's sequential or 4K random performance, the Trion is competitive. However, shift the focus to real-world data duties, and the wheels fall off a little. Just like other drives, we noticed an ominous drop-off in performance when transferring our test files. The internal data copy benchmark duly revealed sluggish performance.

At 4 minutes and 19 seconds for the 30GB copy, it's nearly twice as slow as the best SATA drives, never mind the sub-one-minute performance of some of the PCIe drives. That it's beaten by SanDisk's budget drive in this metric says it all, and makes it very hard to recommend the Trion 100 over a similarly capacious Samsung 850 EVO. It's not a terrible drive. It's just not the SSD we'd buy.

VERDICT
6

OCZ Trion 100 960GB

⊞ **BLACK FRIDAY** Truckloads of capacity; seriously cheap.

⊟ **BLACK MONDAY** Patchy performance; slightly miserly three-year warranty.

$200, www.ocz.com

SAMSUNG
Solid State Drive

Samsung 850 EVO 500GB

The ultimate all-arounder?

IT IS A TRUTH UNIVERSALLY ACKNOWLEDGED that Samsung SSDs kick ass. Right? Samsung has certainly been the dominant figure in the consumer SSD market for the last few years, but things haven't all gone Samsung's way.

The 840 EVO drive, just as a for instance, suffered from some fairly serious bork. Samsung has been forced to release multiple firmware patches for the 840 EVO to address a performance issue that involves access speeds to old data falling off over time. In that context, it's arguably the job of the latest 850 model to rebuild the reputation of Samsung's mainstream "EVO" models.

On paper, the 850 EVO certainly looks like a technical tour de force. For starters, there's snazzy 3D VNAND, which sees layers of memory stacked vertically. It's the same approach as seen in the pricier 850 Pro, though the EVO model has triple-level memory cells, where the Pro sports faster and more robust dual-level cells. The Pro also touts a 10-year warranty to the EVO's five-year cover.

On the other hand, the EVO boasts the newer controller hardware, in the form of the Samsung MGX chip. Anyway, the real contest for the EVO isn't its Samsung sibling, but SATA drives, such as Kingston's HyperX Savage.

For the most part, it's too close to call. But the EVO does separate itself a little from the pack when it comes to 4K random access performance. In CrystalMark, it's the fastest SATA drive for 4K reads and writes bar none, and the second-fastest of any drive for 4K reads. That includes all the fancy PCI Express drives. Yes, even the NVMe-enabled drives. That is a super-impressive result for a mid-range SATA drive.

It's a little less spectacular in our real-world file copy test, logging 2 minutes and 32 seconds. But that's only a few clicks behind the Kingston HyperX Savage, and it's not enough to spoil a great overall performance. Combined with Samsung's excellent drive management software and that five-year warranty, where some of the others only deliver three years, it's one hell of a package.

VERDICT 8

Samsung 850 EVO 500GB

⊞ **BABE RUTH** Solid all-around performance; five-year warranty.

⊟ **MISSPENT YOUTH** It's still just a SATA drive; doesn't do anything spectacular.

$150, www.samsung.com

SAMSUNG
Solid State Drive

Samsung 850 Pro 2TB

Say "hello" to the $1,000 SSD

NEARLY A THOUSAND BUCKS? For a SATA SSD? Really? At least it comes from Samsung, de facto king of solid-state storage. But, still, that's one hell of a price tag.

However, let's put money to one side and have a sniff around this, the latest in Samsung's long line of world-beaters. It's the 850 Pro in mega-meaty 2TB format, and it's absolutely the state of the art when it comes to SATA SSDs. Of course, anything based on the SATA interface will have limitations compared to the new PCI Express generation. Raw bandwidth is limited to about 550MB/s, and the AHCI control protocol used by SATA was conceived for use with magnetic hard disks, not NAND flash drives.

Those caveats aside, the 850 Pro is special. Along with that 2TB capacity, it's worth remembering that Samsung does everything in-house, giving it complete control over integrating the NAND memory with the controller chipset and the firmware. And in-house at Samsung means cutting-edge technology. For the 850 Pro, that includes exotic 3D VNAND, which involves layering the memory in vertical stacks. That doesn't just increase capacity, it creates new opportunities for super-fast interconnects.

The 850 Pro also has one of Samsung's powerful triple-core SATA controllers, the MEX. Combine that with a 10-year warranty, and you have about the most compelling SATA-based storage imaginable, albeit at that price.

The 850 Pro isn't the fastest SATA drive in every single benchmark. It's even beaten on occasion by its cheaper Samsung sibling, the 850 EVO. But it is consistent—it's among the fastest, whatever the benchmark.

The context is SATA drives. The 850 Pro is blown back into 2015 by the next-gen PCI Express drives, including Samsung's 950 Pro. What's more, if you can afford the 850 Pro's price, you might be better off modernizing your PC with support for PCI Express storage, even if that means a new mobo. But if you are committed to sticking with SATA, and you want the fastest, most reliable SSD, backed by a bullet-proof warranty, this is almost definitely it.

VERDICT 8

Samsung 850 Pro 2TB

⊞ **BY GRABTHAR'S HAMMER!** The finest SATA drive money can buy; huge 10-year warranty.

⊟ **CREWMAN NUMBER SIX** It's a SATA drive; it's nearly $1,000; did we mention the $1,000?

$918, www.samsung.com

Samsung 950 Pro M.2 512GB

All your SSD are belong to us

THIS IS IT, RIGHT? The daddy of SSDs. The storage solution to rule them all? The Samsung 950 Pro M.2 512GB certainly looks seriously hot on paper. It all starts with the form factor. It's an M.2 drive, which is rapidly becoming the weapon of choice for high-performance desktop storage.

Of course, it supports the new NVMe storage protocol, and does its high-bandwidth thing via a quad-lane PCI Express 3.0 interface, which allows for GB/s rather than mere MB/s of raw bandwidth. At 512GB, it's big enough to store more than just your OS and a few apps, too.

Oh, and it's a Samsung drive, and Samsung is arguably the most innovative of SSD makers. In fact, it's one of the very few SSD makers that does everything itself. NAND memory, controller chipset, firmware, assembly, the lot.

In this case, you get Samsung's UBX controller chipset and fancy 3D NAND memory. The claimed performance is consequently spectacular: 2.5GB/s for reads and 1.5GB/s writes are the headline figures, but the 300,000 read IOPS claim is a bit of an eyebrow tweaker, too. Anyway, it all begs the obvious question. What'll she do, mister?

In benchmarks such as ATTO and CrystalMark, you'll get peak sequential numbers quite near the claimed performance. In other words, really big numbers. In terms of random access performance, there's a similarly big leap over conventional SATA drives, with 4K read speeds around the 200MB/s mark. Write speeds are only slightly better than a SATA drive, at about 50MB/s.

However, the 950 doesn't play so nicely with the AS SSD benchmark if you're using the default Windows NVMe driver. Samsung's own NVMe driver tidies things up. Back in the real world, the 950 delivers the fastest time in our file copy test, at just 43 seconds. Compare that to over six minutes for the slowest SATA drive, and you get an idea of just how much more performance potential this offers.

So it's seriously quick, the 950 Pro. But remember, you need a motherboard that offers a proper four-lane PCIe M.2 slot to make the most of its awesome performance.

VERDICT
9
KICK ASS!

Samsung 950 Pro M.2 512GB

⊞ **ALL YOUR BASE** Crazy-fast all-around performance; cutting-edge hardware.

⊟ **SET US UP THE BOMB** Not exactly cheap; unspectacular 4K read performance.

$329, www.samsung.com

SanDisk SSD PLUS 240GB

The little SSD that can

THIS THING HAS NO RIGHT being any good. Price-wise, it's right at the bottom of the food chain, and you absolutely know it from the moment you crack open the packaging. It feels hideously light and hollow.

There's no iFixit-style teardown for these reviews, but we suspect that if you prized open the flimsy plastic chassis, you'd find almost nothing but air. The PCB will be tiny. That's partly because this drive is one of a new breed of what's sometimes known as "DRAM-less" SSDs.

This drive uses Silicon Motion's SM2246XT controller, which is low cost, thanks to omitting a DRAM memory controller. The controller still has some internal SRAM cache, but on paper the SSD PLUS looks like a corner-cutting exercise. At least, it does save for one detail: It's a SanDisk drive, and SanDisk doesn't usually ruin its drives with bad corner-cutting decisions. Then you spot the MLC rather than TLC NAND memory. Things are looking up.

Of the really low-cost drives here, the SSD PLUS is the only one that can sustain full write speeds for extended periods. In fact, it doesn't suffer from any conspicuous performance nasties. OK, its peak performance is miles away from the PCIe hotness delivered by some of the snazziest SSDs. Indeed, depending on which benchmark you choose, it's a fair way behind the quicker SATA SSDs, such as the Samsung 850 Pro, too. But consider this: If your file copying takes nearly three minutes instead of just under two and a half, will you notice? Probably not. What might bother you is if it takes over six minutes.

In practice, this bargain basement drive gives a subjective user experience that you'd probably struggle to pick from premium SATA drives. There will be exceptions to that. If you routinely rely on applications that make heavy use of your storage, paying a little extra for a premium SATA drive or making that big jump to an NVMe-enabled PCI Express drive can certainly be worthwhile. But for most of us, most of the time, this SanDisk SSD PLUS gets the job done. It's good enough at a great price.

VERDICT
7

SanDisk SSD PLUS 240GB

⊞ **FOREST GUMP** Keeps on trucking; sometimes on sale for super cheap.

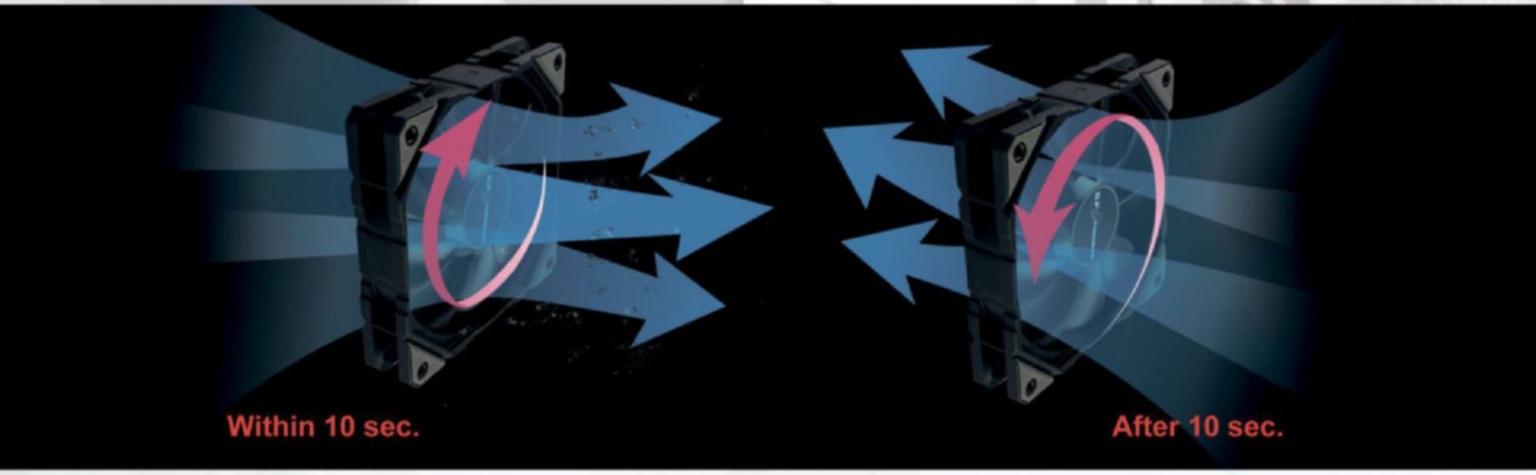
⊟ **WORTHLESS CHUMP** Low-spec hardware; mediocre sequential throughput.

$65, www.sandisk.com

ENERMAX
POWER. INNOVATION. DESIGN.

2016 Innovation

Patented Dust Free Rotation (DFR) Technology


Within 10 sec.
After 10 sec.

Automatic Dust Cleaning Solution
Keep your gaming rig ready for battle

D.F. PRESSURE
ENERMAX
Platimax D.F.
OSTROG

D.F. PRESSURE

Super High
Air Pressure
(4.812mm-H_2O)

ETS-T50 AXE

TDP 250W.
Patented PDF & Air Guide
to optimize the airflow

Platimax D.F.

Full modular design
100% 105C JPN Cap
Twister Bearing Fan

OSTROG ADV

MaxBrite™ technlogy brings
the world first case with
LED lighting in the front
and top panel!

HOW WE TESTED

Of all the major PC components, SSDs are the trickiest to test. That's because a full assessment of their long-term reliability takes years of data bombardment. However, what we give you is an accurate picture of ongoing performance. Our benchmark picks include a wide range of synthetic tests. Some may look similar, but each has its own little tweaks and nuances. And remember—those 4K random numbers are just as important as the headline-grabbing sequential data transfer results. We also have a little sniff around real-world performance. Simple file copies can reveal a surprising amount about underlying drive performance.

SPECIFICATIONS

	Capacity	Interface	Control protocol	Manufacturer	Warranty	Website	Price
Crucial BX200 960GB	960GB	SATA	AHCI	Crucial	Three years	www.crucial.com	$260
Intel 750 Series 400GB	400GB	PCI Express	NVMe	Intel	Five years	www.intel.com	$299
Kingston HyperX Savage 240GB	240GB	SATA	AHCI	Kingston	Three years	www.kingston.com	$120
Kingston Predator M.2 HH-HL 480GB	480GB	PCI Express	AHCI	Kingston	Three years	www.kingston.com	$300
Kingston SSDNow V300 120GB	120GB	SATA	AHCI	Kingston	Three years	www.kingston.com	$42
OCZ Trion 100 960GB	960GB	SATA	AHCI	OCZ	Three years	www.ocz.com	$200
Samsung 850 Evo 500GB	500GB	SATA	AHCI	Samsung	Five years	www.samsung.com	$150
Samsung 850 Pro 2TB	2TB	SATA	AHCI	Samsung	Ten years	www.samsung.com	$918
Samsung 950 Pro M.2 512GB	512GB	M.2	NVMe	Samsung	Five years	www.samsung.com	$329
SanDisk SSD PLUS 240GB	240GB	SATA	AHCI	SanDisk	Three years	www.sandisk.com	$65

SPECIFICATIONS CONTINUED

	Controller	NAND type	Sequential read	Sequential write	Read IOPS	Write IOPS
Crucial BX200 960GB	Silicon Motion SM2256	16nm TLC	540MB/s	490MB/s	66K	78K
Intel 750 Series 400GB	Intel CH29AE41AB0	20nm MLC	2.2GB/s	900MB/s	430K	230K
Kingston HyperX Savage 240GB	Phison PS3110-S10	19nm MLC	560MB/s	530MB/s	100K	89K
Kingston Predator M.2 HH-HL 480GB	Marvell 88SS9293	19nm MLC	1.4GB/s	1GB/s	130K	118K
Kingston SSDNow V300 120GB	SandForce SF-2281	19nm MLC	450MB/s	450MB/s	85K	55K
OCZ Trion 100 960GB	Toshiba TC58	19nm TLC	550MB/s	530MB/s	90K	64K
Samsung 850 Evo 500GB	Samsung MGX	40nm TLC VNAND	540MB/s	520MB/s	98K	90K
Samsung 850 Pro 2TB	Samsung MHX	40nm MLC VNAND	550MB/s	520MB/s	100K	90K
Samsung 950 Pro M.2 512GB	Samsung UBX	40nm MLC VNAND	2.5GB/s	1.GB/s	300K	110K
SanDisk SSD PLUS 240GB	Silicon Motion SM2246XT	19nm MLC	520MB/s	350MB/s	81K	81K

BENCHMARKS

	30GB Copy	5GB Zip	AS SSD MB/s Sequential Read	AS SSD MB/s Sequential Write	AS SSD MB/s 4K Read	AS SSD MB/s 4K Write
Crucial BX200 960GB	6 mins 27 secs	3 mins 16 secs	498	445	26	101
Intel 750 Series 400GB	54 secs	3 mins 16 secs	1,871	917	35	206
Kingston HyperX Savage 240GB	2 mins 26 secs	3 mins 16 secs	501	487	39	100
Kingston Predator M.2 HH-HL 480GB	1 min 7 secs	3 mins 16 secs	1,344	910	39	109
Kingston SSDNow V300 120GB	6 mins 47 secs	3 mins 16 secs	461	132	14	98
OCZ Trion 100 960GB	4 mins 19 secs	3 mins 16 secs	501	433	34	91
Samsung 850 Evo 500GB	2 mins 32 secs	3 mins 10 secs	490	479	39	109
Samsung 850 Pro 2TB	2 mins 15 secs	3 mins 16 secs	489	481	40	110
Samsung 950 Pro M.2 512GB	**43 secs**	**3 mins 13 secs**	**2,028**	**1,419**	45	162
SanDisk SSD PLUS 240GB	2 mins 42 secs	3 mins 16 secs	495	347	15	101

BENCHMARKS CONTINUED

	ATTO MB/s Sequential Read	ATTO MB/s Sequential Write	CrystalMark MB/s Sequential Read	CrystalMark MB/s Sequential Write	Crystal-Mark MB/s 4K Read	Crystal-Mark MB/s 4K Write
Crucial BX200 960GB	559	492	541	448	34	123
Intel 750 Series 400GB	2,351	996	1,148	985	40	334
Kingston HyperX Savage 240GB	564	544	549	508	30	125
Kingston Predator M.2 HH-HL 480GB	1,556	1,015	1,375	1,008	41	139
Kingston SSDNow V300 120GB	554	524	448	139	20	121
OCZ Trion 100 960GB	562	530	540	460	29	116
Samsung 850 Evo 500GB	550	521	506	488	45	137
Samsung 850 Pro 2TB	563	535	540	516	40	136
Samsung 950 Pro M.2 512GB	**2,609**	**1,549**	**2,210**	**1,539**	51	198
SanDisk SSD PLUS 240GB	555	384	512	377	25	120

SAMSUNG
SSD 950
PRO M.2
3D V-NAND

And the winner is…

Samsung 950 Pro M.2 512GB

TEN DRIVES, three format factors, and a whole lot of benchmarks. But what have we learned? For starters, it's obvious that this brave new age of PCI Express storage throws up compatibility problems.

During the SATA era, you could buy pretty much any SSD and sling it into your rig, confident that it wouldn't just be physically compatible, but that you would also be able to boot from it. That's not true with drives that use the PCI Express interconnect and the NVMe control protocol. M.2 and U.2 drives require ports and connectors that may not be present on your motherboard.

Likewise, while pure PCI Express SSDs, such as Intel's 750 Series, will physically plug into almost any board, you'll need support for the NVMe protocol. That's far from guaranteed with any given motherboard. And the older the board, the less likely you are to be in luck. All of which means that the supposed choice between many of these drives may be academic, short of a major system upgrade.

BUILD ON SUCCESS

It also means that SATA drives aren't dead. Not for a lot of us. In that category, the relative duds are the Kingston SSDNow V300, the OCZ Trion 100, and the Crucial BX200. All of them stumble when it comes to sustained data transfers. As it happens, the ability to keep on trucking is what makes SanDisk's SSD PLUS budget drive so impressive. If you want a decent drive that's seriously cheap, it's a nice choice.

Of the mid-range SATA offerings, it's a surprisingly tightly fought contest between our established SSD honey, the Samsung 850 EVO, and Kingston's HyperX Savage. For pure SSD properties, we would happily take the Samsung over the Kingston. As an overall package, however, the Kingston's extras—including that useful USB 3.0 enclosure—are mighty appealing. Pay your money, take your pick. As for the Samsung 850 Pro, it's as good as SATA drives get, but at a price, especially in 2TB format.

Moving on to the PCI Express category, Kingston's Predator carves out a nice little niche for itself, thanks to omitting support for the NVMe control protocol. That probably compromises its performance a little bit, but it also broadens motherboard compatibility. It's an interesting drop-in option for systems that don't support NVMe, even if you still need to take care regarding compatibility and bootability. Due diligence before purchase is a must.

And so it ultimately comes down to two drives fighting it out for the title of the hottest, the fastest, the downright best solid-state drive in town. Yup, our final decision is between Intel's 750 Series and the Samsung 950 M.2. For some, the choice may be dictated by form factor. Both drives support NVMe, but the Intel offering is compatible with a wider range of motherboards, thanks to being a simple PCI Express board, rather than an M.2 card. It's the obvious choice if your motherboard supports NVMe but lacks an M.2 slot. However, if we were building our ultimate PC from scratch, M.2 compatibility would be a given. So there can be only one—it's the awesome Samsung 950 Pro.

ZALMAN
COOL INNOVATIONS

facebook.com/zalmanusa
www.zalman.com

Z11 NEO

Z9 NEO
WHITE

ZM1000-EBT
80 Plus Gold Rated PSU

H1
Full Tower ATX Case

ZM-K700M
Mechanical Keyboard

ZM-GM4
Adjustable Custom Fit Mouse

CNPS10X OPTIMA
Performance CPU Cooler

www.newegg.com
www.frys.com
www.amazon.com
www.memoryexpress.com
www.microcenter.com
www.ncix.com
www.directron.com
www.quitepc.com

WINDOWS 10 COMMAND-LINE TRICKS

Get savvy with the Command Prompt, with help from *Nick Peers*

The Windows Command Prompt is at once both powerful and often overlooked. It harks back to the days of DOS and the command-line, and continued to play a major role in early versions of Windows. Over time, it's been forced into the background, as Microsoft has pushed bells and whistles, but the Command Prompt has never been ignored, and continues to play an important role, particularly when troubleshooting.

The big headlines may have gone to the new Windows 10 user interface, or some of its more crowd-pleasing features, but the Command Prompt has continued to be nurtured by the Microsoft boffins, and Windows 10 introduced a number of handy improvements to the console window, making it more accessible and easy to use.

You can now resize the console window more easily, simply through drag-and-drop—no more messing about with console buffer size settings (although you still can, if you prefer). Word wrap means text doesn't get lost off-screen, forcing you to horizontally scroll to read particularly long lines of text. You can now easily select parts of the console output with your mouse, and copy them to the clipboard with just one click (or, more precisely, one right-click). There are even useful new text selection key combinations, helping speed things up further, too.

But even without these handy new features, the Command Prompt remains a powerful and vital tool in any self-respecting PC user's armory. So why let Linux have all the fun with its Terminal, when you can give your computer some command-line love in Windows, too? Join us as we dissect the Command Prompt, and reveal how best to make use of it. You'll never look at your mouse (or the Windows desktop) in quite the same way again.

Programs and Features
Power Options
Event Viewer
System
Device Manager
Network Connections
Disk Management
Computer Management
Command Prompt
Command Prompt (Admin)
Task Manager
Control Panel
File Explorer
Search
Run
Shut down or sign out
Desktop
Run

Type the name of a program, folder, document or Internet resource, and Windows will open it for you.

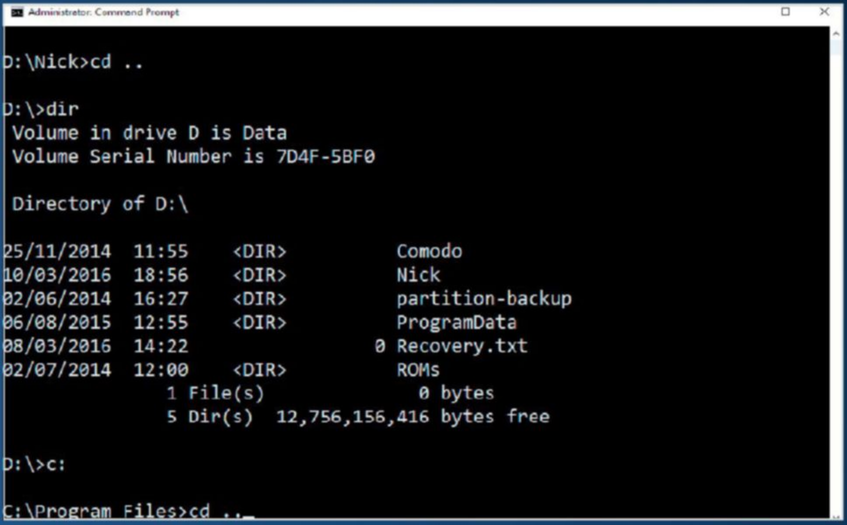
Open: cmd

OK
Cancel
Browse...

Access to the Command Prompt is easy. If you don't need administrator-level access, press Win-R, type **cmd**, and hit Enter, or search for "cmd" in the Cortana search box. Alternatively, right-click the Start button, where you'll find two options: "Command Prompt" and "Command Prompt (Admin)." The latter launches Command Prompt as an administrator, giving you access to the full gamut of options.

Once the window opens, you'll find yourself staring at the Windows command-line, which will be a familiar sight to those who remember DOS, or who have had experience with the Linux shell. In the past, the Command Prompt was strictly a keyboard-only affair, but with Windows 10, Microsoft has added some mouse-selection features, it has expanded the way you can select, too. For example, hold Shift and use the arrow keys to select characters to the left and right, or lines up and down. Use Shift-Home and End to extend selections to the margin, and Shift-PageDown or PageUp to select entire screens. Throw in Ctrl with each of these shortcuts (so Ctrl-Shift), and the selection goes further—words, paragraphs, and even the entire screen buffer.

Before going any further, check out the box on customizing the Command Prompt interface, on page 42. By default, text is rendered quite small, so you'll be pleased to learn you can customize most aspects of the window—font, size, color, background, and so on.



```
D:\Nick>cd ..

D:\>dir
 Volume in drive D is Data
 Volume Serial Number is 7D4F-5BF0

 Directory of D:\

25/11/2014  11:55    <DIR>          Comodo
10/03/2016  18:56    <DIR>          Nick
02/06/2014  16:27    <DIR>          partition-backup
06/08/2015  12:55    <DIR>          ProgramData
08/03/2016  14:22                 0 Recovery.txt
02/07/2014  12:00    <DIR>          ROMs
               1 File(s)              0 bytes
               5 Dir(s)  12,756,156,416 bytes free

D:\>c:

C:\Program Files>cd ..
```

You can quickly and easily switch folders.

What can you do with the Command Prompt? There are dozens of useful commands you can input, and we're showcasing the best of them in this guide. Before continuing, though, it helps to understand how commands are broken down, known as the command syntax. There's the command itself, of course, but it's usually followed by a number of options, some compulsory (in that you must choose at least one), others optional. These options are context-sensitive—they might refer to a path or filename, as is the case with the **recimg** command for creating a recovery image, or they may refer to various "flags," which instruct the command to work in a specified way—for example, adding **-v** to a command, such as **driverquery**, usually tells it to output the command's results in "verbose" or detailed mode, rather than as a basic summary. Note: Unlike with Linux, flags aren't case-sensitive, so typing **-v** or **-V** results in the same thing.

Find your way around

Let's delve into the Command Prompt proper. First, you'll notice that it opens in one of two locations—if you invoke it as a normal user, it opens inside your personal user folder; if you launch it as an administrator, it defaults to the Windows\System32 directory. You're not stuck in this folder—the Command Prompt has all the tools you need, not just for navigating through your file system, but also moving, copying, and deleting files, too. We'll start

System File Checker

One of the best-known Command Prompt tools is System File Checker (SFC), and most know that typing **sfc /scannow** should, in theory at least, detect any corrupt system files and replace them with working backups. It's not always successful in repairing all files—if you get a message telling you that Windows Resource Protection was unable to fix all the corrupt files it found, try the following.

First, generate a text file with the information required to track down the files SFC couldn't fix:

```
findstr /c:“[SR]” %windir%\Logs\CBS\
CBS.log >“%userprofile%\Desktop\
sfcdetails.txt”
```

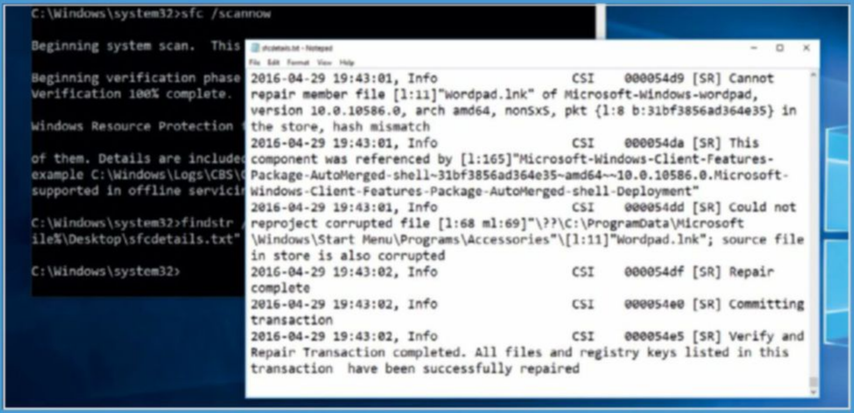
Now open the sfcdetails.txt file—this is a filtered view of the CBS.log, containing only those files SFC couldn't fix. Identify the corrupt files, and source working versions from another PC that's running the same version of Windows. Now issue the following commands for each corrupt file, replacing **<path>** with the file's path (such as **C:\Windows\System32**), and **<corruptfile>** with its full filename (**jscript.dll**):

```
takeown /f <path>\<corruptfile>
  icacls <path>\<corruptfile> /
GRANT ADMINISTRATORS:F
```

Finally, copy the file you took from the other PC into the same folder, overwriting this one when prompted:

```
copy <sourcepath>\<sourcefile>
<path>\<corruptfile>
```

Run SFC again, which should now verify there are no corrupt files that require replacing. For more information, see https://support.microsoft.com/kb/929833.



```
C:\Windows\system32>sfc /scannow

Beginning system scan.  This

Beginning verification phase
Verification 100% complete.

Windows Resource Protection

of them. Details are include
example C:\Windows\Logs\CBS\
supported in offline servici

C:\Windows\system32>findstr
ile%\Desktop\sfcdetails.txt"

C:\Windows\system32>
```

```
2016-04-29 19:43:01, Info                  CSI    000054d9 [SR] Cannot
repair member file [l:11]"Wordpad.lnk" of Microsoft-Windows-wordpad,
version 10.0.10586.0, arch amd64, nonSxS, pkt {l:8 b:31bf3856ad364e35} in
the store, hash mismatch
2016-04-29 19:43:01, Info                  CSI    000054da [SR] This
component was referenced by [l:165]"Microsoft-Windows-Client-Features-
Package-AutoMerged-shell~31bf3856ad364e35~amd64~~10.0.10586.0.Microsoft-
Windows-Client-Features-Package-AutoMerged-shell-Deployment"
2016-04-29 19:43:01, Info                  CSI    000054dd [SR] Could not
reproject corrupted file [l:68 ml:69]"\??\C:\ProgramData\Microsoft
\Windows\Start Menu\Programs\Accessories"\[l:11]"Wordpad.lnk"; source file
in store is also corrupted
2016-04-29 19:43:02, Info                  CSI    000054df [SR] Repair
complete
2016-04-29 19:43:02, Info                  CSI    000054e0 [SR] Committing
transaction
2016-04-29 19:43:02, Info                  CSI    000054e5 [SR] Verify and
Repair Transaction completed. All files and registry keys listed in this
transaction  have been successfully repaired
```

> **Robocopy** is designed to copy multiple files and folders in one go—it's complicated to set up, but incredibly powerful.

with the **dir** command—type this and it lists all the files and folders in the current folder. Hidden folders don't show up—to make these appear, use **dir /A:H**. The **/A** flag instructs **dir** to show files containing whichever attributes are listed after it—**H** refers to hidden files, while other attributes you can use include **R** (read-only files), **D** (directories), and **S** (system files). Type **dir /A:HD**, and hidden directories are shown instead of hidden files.

There are lots of other useful flags you can apply to **dir**, too—but how can you find out about them? Simple, either type **dir /?** or **help dir**, and a handy cheatsheet appears, providing a description of the command, what options it supports, and then giving a summary of each option, such as **/q**, which lists the owner of the file or folder, in addition to other stats.

Want to know how your folder is broken down into subfolders? Use the **tree** command, and you'll see a tree-like hierarchy of all the subfolders inside the current folder—pair **tree** with a specific path, and it shows you the hierarchy for the selected folder.

Want to move to a different directory? Type **cd**, followed by the full path of the folder you wish to visit (enclose paths in double quotes if there's a space in the name), and you'll jump straight there—for example, **cd "c:\program files"**. You can also substitute the path with an environment variable—use **cd %appdata%** to jump to the AppData\Roaming folder inside your personal user folder, for instance. You can also move up and down your folder hierarchy—use **cd <folder>** to enter a subfolder inside the current folder, or type **cd ..** to move up one level.

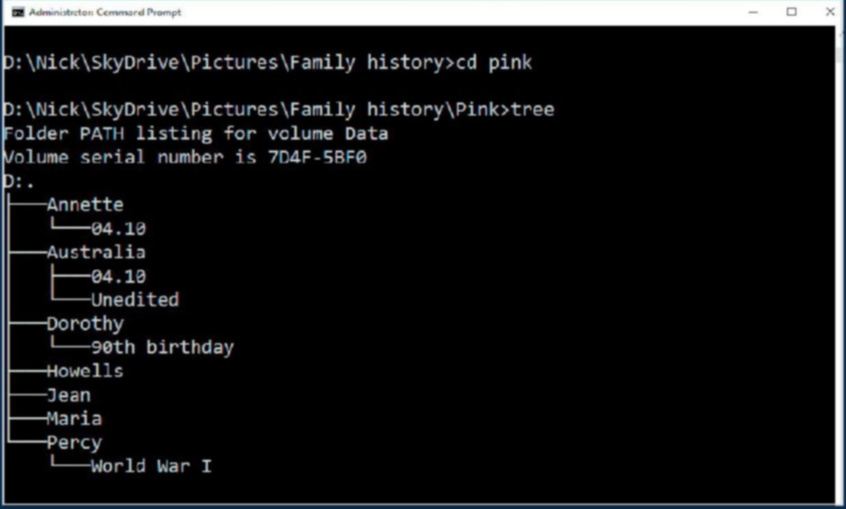
If you want to switch to a different drive, you'll find the **cd** command has no effect—simply type the drive letter (such as **d:**), and hit Enter, then use the **cd** command to navigate to your desired folder.

Copy, move, delete

It's possible to copy, move, rename, and delete files and directories with the Command Prompt, too—use **copy**, **rename**, and **move** for individual files and folders, plus **del** to delete individual files. If you need to delete everything in a folder, use the ***** wildcard—for example, **del *.*** deletes every single file in the current folder. It goes without saying, you should proceed with caution—we suggest sticking with File Explorer when it comes to working with files and folders, unless there's no alternative, or you want to verify files you copy—in which case, use the **verify on** command to do so (and, yes, **verify off** switches this off again).

You can manage folders, too: **md** creates a folder, while **rmdir** removes it. If you plan to delete a folder that isn't empty, use **rmdir /s <directory>** to delete it and its contents. Also, investigate the **robocopy** command, which is designed to copy multiple files and folders in one go—it's very complicated to set up, but is incredibly powerful, too, giving you all kinds of filters and options, such as **/nocopy** (remove all file information from the copied files), and **/b** (backup mode, which allows administrators to copy files they would normally be denied access to). A number of GUI frontends have been developed, but only one is currently available, the commercial GS RichCopy 360 (www.gurusquad.com).

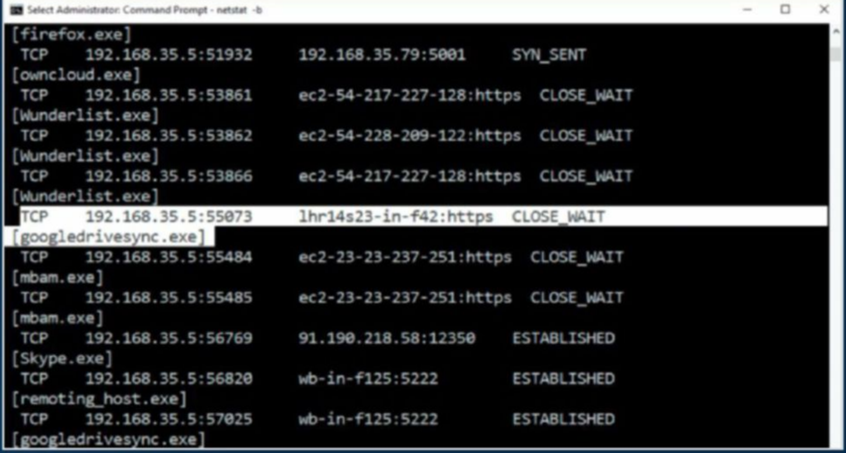
Need to format a drive from the Command Prompt? Use the aptly titled **format** command. To quickly format the current drive using the same file system, use **format <vol> /Q**, where **<vol>** is the drive letter (such as **d:**) of the target drive. Other options include **/FS** (specify file system, including FAT, FAT32, exFAT and NTFS), **/V:** (assign a drive label), and **/C** (compress all files on this volume, this requires NTFS). Like file management, formatting drives is usually best done from within File Explorer itself. Other



```
D:\Nick\SkyDrive\Pictures\Family history>cd pink

D:\Nick\SkyDrive\Pictures\Family history\Pink>tree
Folder PATH listing for volume Data
Volume serial number is 7D4F-5BF0
D:.
├───Annette
│   └───04.10
├───Australia
│   ├───04.10
│   └───Unedited
├───Dorothy
│   └───90th birthday
├───Howells
├───Jean
├───Maria
└───Percy
    └───World War I
```

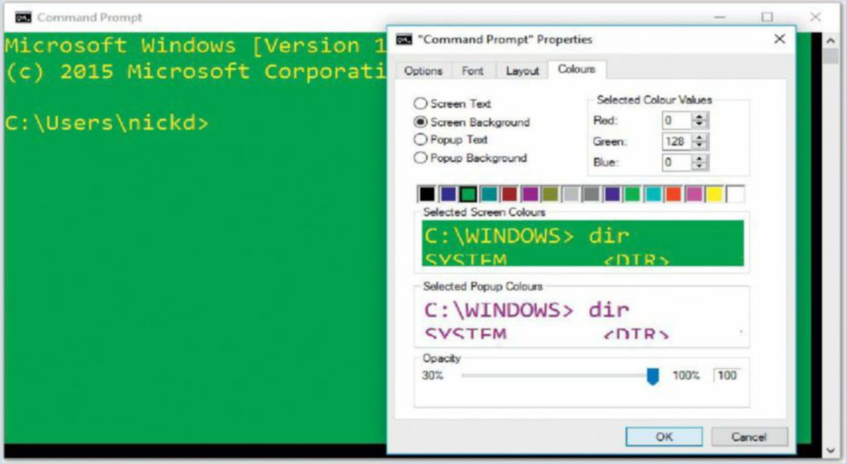
The "tree" command provides a hierarchical view of any folder.



```
[firefox.exe]
 TCP    192.168.35.5:51932     192.168.35.79:5001     SYN_SENT
[owncloud.exe]
 TCP    192.168.35.5:53861     ec2-54-217-227-128:https  CLOSE_WAIT
[Wunderlist.exe]
 TCP    192.168.35.5:53862     ec2-54-228-209-122:https  CLOSE_WAIT
[Wunderlist.exe]
 TCP    192.168.35.5:53866     ec2-54-217-227-128:https  CLOSE_WAIT
[Wunderlist.exe]
 TCP    192.168.35.5:55073     lhr14s23-in-f42:https  CLOSE_WAIT
[googledrivesync.exe]
 TCP    192.168.35.5:55484     ec2-23-23-237-251:https  CLOSE_WAIT
[mbam.exe]
 TCP    192.168.35.5:55485     ec2-23-23-237-251:https  CLOSE_WAIT
[mbam.exe]
 TCP    192.168.35.5:56769     91.190.218.58:12350    ESTABLISHED
[Skype.exe]
 TCP    192.168.35.5:56820     wb-in-f125:5222        ESTABLISHED
[remoting_host.exe]
 TCP    192.168.35.5:57025     wb-in-f125:5222        ESTABLISHED
[googledrivesync.exe]
```

Use "netstat" to find out which programs are opening ports.

Customize the Command Prompt



```
Microsoft Windows [Version 1
(c) 2015 Microsoft Corporati

C:\Users\nickd>
```

○ Screen Text
● Screen Background
○ Popup Text
○ Popup Background

Selected Colour Values
Red: 0
Green: 128
Blue: 0

Selected Screen Colours

```
C:\WINDOWS> dir
SYSTEM          <DIR>
```

Selected Popup Colours

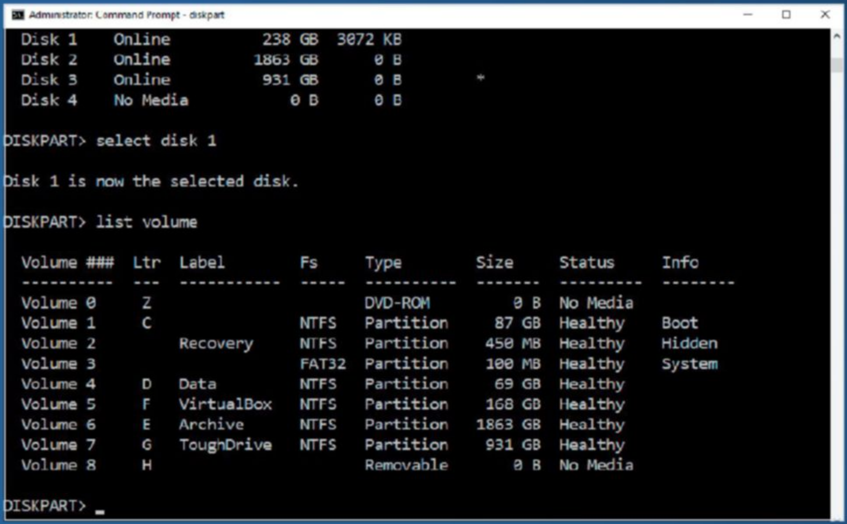
```
C:\WINDOWS> dir
SYSTEM          <DIR>
```

Opacity
30% 100% 100

Before delving too deep into the Command Prompt utility, take the time to customize its appearance to your personal comfort. To do this, right-click the Command Prompt icon on its menu bar, and choose "Properties." You'll see options spread out over four tabs: "Font" controls the text type, size, and style, while "Colors" lets you change the background and text colors, plus make the window semi-transparent (we're not sure why you'd want to, but each to their own).

The "Layout" tab enables you to set the window size in lines (height) and text characters (width), while the Screen Buffer Size height reveals how many lines you can scroll through. The default size should be sufficient—make sure you leave the "Wrap text output on resize" option ticked.

The main tab—"Options"—enables you to tweak the command buffer (this is basically your command "history," and you can cycle through previous commands using the up cursor key). You can also change the mouse cursor size, plus enable or disable various features, many of which are new to Windows 10, such as the ability to copy and paste selected text using the keyboard ("Enable Ctrl key shortcuts"). If you're resolutely old-school, you can tick ‘"Use legacy console," and do without these feature improvements, but in the majority of cases, we suggest leaving well alone.



```
  Disk 1    Online          238 GB  3072 KB
  Disk 2    Online         1863 GB      0 B
  Disk 3    Online          931 GB      0 B        *
  Disk 4    No Media          0 B       0 B

DISKPART> select disk 1

Disk 1 is now the selected disk.

DISKPART> list volume

  Volume ###  Ltr  Label        Fs     Type        Size     Status     Info
  ----------  ---  -----------  -----  ----------  -------  ---------  --------
  Volume 0     Z                       DVD-ROM         0 B  No Media
  Volume 1     C                NTFS   Partition     87 GB  Healthy    Boot
  Volume 2         Recovery     NTFS   Partition    450 MB  Healthy    Hidden
  Volume 3                      FAT32  Partition    100 MB  Healthy    System
  Volume 4     D   Data         NTFS   Partition     69 GB  Healthy
  Volume 5     F   VirtualBox   NTFS   Partition    168 GB  Healthy
  Volume 6     E   Archive      NTFS   Partition   1863 GB  Healthy
  Volume 7     G   ToughDrive   NTFS   Partition    931 GB  Healthy
  Volume 8     H                       Removable       0 B  No Media

DISKPART> _
```

Diskpart is a powerful—and potentially dangerous—tool.

drive-related commands worth exploring include **fsutil**, which is a suite of commands offering various tasks for FAT32 and NTFS file systems. Type **fsutil** and you'll see a list of supported commands—use **fsutil <command>** to run one (at which point, you're shown a list of supported options for that subcommand). Keep typing and more options may show—eventually, you'll be able to enter a command such as **fsutil fsinfo volumeinfo c:** to find out useful info about your main system drive, such as its file system, and what features it supports (such as disk quotas and hard links).

If you want to convert a drive from FAT32 to NTFS without losing any of your data, use the **convert** command. Type **convert <vol> /fs:ntfs**—if the drive is mounted, you may need to add the **/x** flag to force a dismount, or otherwise reboot if you're converting your Windows system drive. Also consider adding **/nosecurity** if you want the converted files to be universally accessible to all users: **convert d: /fs:ntfs /nosecurity**.

If you want to check a drive for errors, you'll probably remember the **chkdsk** tool from earlier versions of Windows. It's still there in Windows 10—use it on its own to simply scan the current drive, or specify the drive you wish to scan, plus add the **/r** flag if you wish to both fix problems and attempt to recover readable information from bad sectors—for example, **chkdsk d: /r**. If the drive is in use, you're prompted to schedule the check for the next time you restart Windows.

A related tool is **chkntfs**—by default, Windows runs **chkdsk** at boot time on any drive found to be "dirty," but you can use this in conjunction with the specified drive and the **/x** flag to exclude it from the boot-time check, or **/c** to schedule it specifically for checking at boot time if it's dirty. A handy flag to remember is **/d**—this returns things to normal, namely checking all drives at boot that are flagged dirty.

Get info and troubleshoot

Want a summary of information about your system? Use the **systeminfo** command,

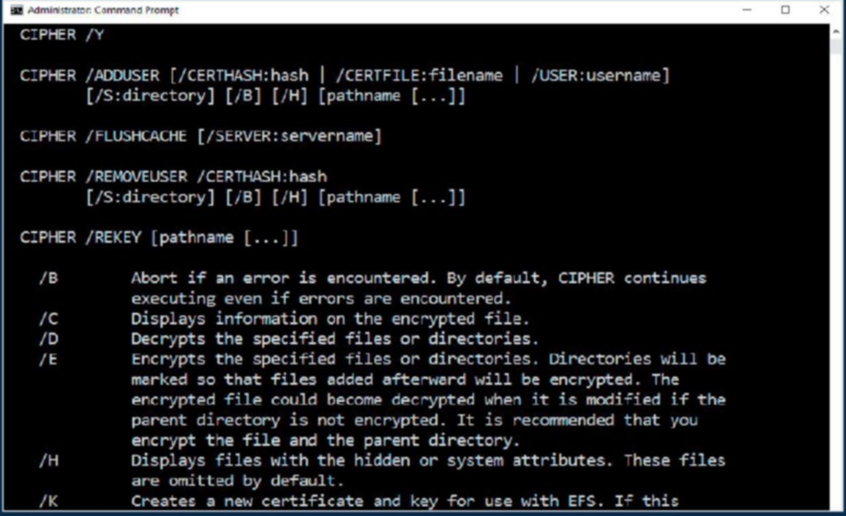
> Device Manager focuses on hardware drivers only, whereas **driverquery** includes software drivers, too.

which, aside from the usual stuff, can reveal useful snippets, such as when Windows was first installed, and which hotfixes have been added. It can also be used to see whether your PC is capable of Hyper-Virtualization, too.

There are other, more focused information tools, as well. Use **ipconfig** to get information about your local network settings—use the **/all** flag for more detailed information. Also, **ipconfig** can be used to fix certain connectivity problems—use **/release** to release the IPv4 address (**/release6** works with your network's IPv6 address, if applicable), and **/renew** or **/renew6** to effectively reset it. The **ipconfig /flushdns** may also work when struggling to resolve domain names over the Internet. Where more than one network interface is present (often on PCs with virtualization software installed), you can also specify the adapter after your flag: **ipconfig /renew Ethernet**, for example.

Another command that can also prove useful when troubleshooting network and Internet connectivity is **ping**, which can be used to verify connections between local network devices or websites—use it in conjunction with the device name, its local IP address, web address, or remote IP address. If you ping using a domain or device name, you're also told its IP address (such as 89.167.142.38 for pcgamer.com, for example).

If the connection works, but is sluggish, use the **tracert** command in place of **ping**—doing so reveals the complete route between you and your target, as well as connection times for each part of the connection, helping you target the middleman causing your problem. Want to know which ports are open on your PC, and where they point? Use the **netstat** command. Try **netstat -b** while running as an administrator if you want to find out more about which program or process has opened which port—it's a slow process, but worth it if you're wondering why a particular port is open.



```
CIPHER /Y

CIPHER /ADDUSER [/CERTHASH:hash | /CERTFILE:filename | /USER:username]
       [/S:directory] [/B] [/H] [pathname [...]]

CIPHER /FLUSHCACHE [/SERVER:servername]

CIPHER /REMOVEUSER /CERTHASH:hash
       [/S:directory] [/B] [/H] [pathname [...]]

CIPHER /REKEY [pathname [...]]

  /B        Abort if an error is encountered. By default, CIPHER continues
            executing even if errors are encountered.
  /C        Displays information on the encrypted file.
  /D        Decrypts the specified files or directories.
  /E        Encrypts the specified files or directories. Directories will be
            marked so that files added afterward will be encrypted. The
            encrypted file could become decrypted when it is modified if the
            parent directory is not encrypted. It is recommended that you
            encrypt the file and the parent directory.
  /H        Displays files with the hidden or system attributes. These files
            are omitted by default.
  /K        Creates a new certificate and key for use with EFS. If this
```

Cipher does more than simply wipe free space.

Need information about drivers on your PC? Device Manager focuses on hardware drivers only, whereas the **driverquery** command includes software drivers, too, such as those installed by your security software and virtualization tool. These are marked as "File System" drivers, and if you want more information, use the **-v** flag for detailed data about each driver, including where its files are on your hard drive.

The **-v** flag produces an awful lot of information, so be sure to check the box below to find out how to review this more efficiently, either by scrolling a page at a time, or by outputting it to a text file.

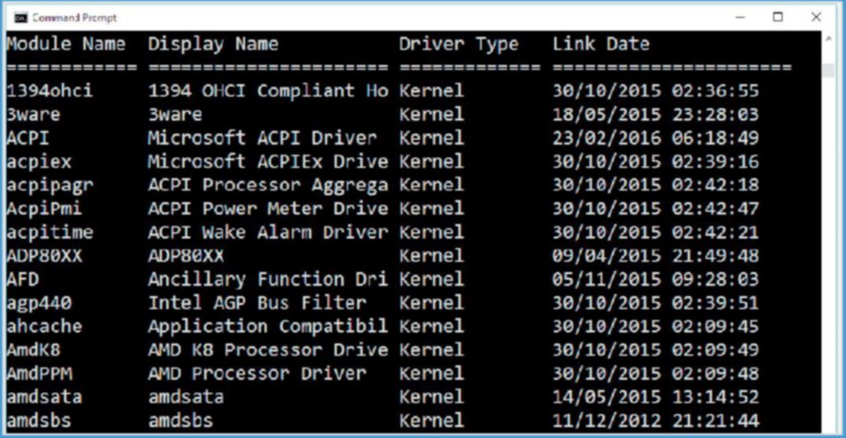
The final tool in this section may already be familiar to you—**powercfg** gives you access to much the same information (and options) as you would find in the Power Options Control Panel, but there are some useful options that you can only find here. Start with **powercfg /a**, which provides a useful summary of which sleep states are supported on your PC. One handy

Command Prompt Tips and Tricks

Windows 10 introduces some handy time-saving features to the Command Prompt, including QuickEdit mode (actually introduced in Windows 8, but let's not split hairs). This enables you to select and copy text from the console quickly, using the mouse—click and drag to select, then right-click to copy it to the clipboard. Place your cursor where you wish to paste it in the console, and right-click again.

Many commands generate pages and pages of data—to save you the onerous task of scrolling back up to review them, add the **| more** option on to the end of offending commands, to force them to show the first page, then pause—from here, press Enter to move down a line at a time, or Space to scroll through the next page. Alternatively, redirect the information to a text file with the ">" switch—for example, **drivequery -v >drivers.txt** creates the file in your current directory.

Some commands can appear to get stuck or keep on looping—break out of them without closing the Command Prompt window by simply pressing Ctrl-C. Want to clear the screen buffer and start with a fresh new "page"? Type **cls** and hit Enter. The Command Prompt also keeps a handy history of previous commands—how many is configured via the "Options" tab under Command Prompt Properties, which you can cycle through using the up and down cursor keys, speeding up text entry.



```
Module Name  Display Name           Driver Type   Link Date
============ ====================== ============= ======================
1394ohci     1394 OHCI Compliant Ho Kernel        30/10/2015 02:36:55
3ware        3ware                  Kernel        18/05/2015 23:28:03
ACPI         Microsoft ACPI Driver  Kernel        23/02/2016 06:18:49
acpiex       Microsoft ACPIEx Drive Kernel        30/10/2015 02:39:16
acpipagr     ACPI Processor Aggrega Kernel        30/10/2015 02:42:18
AcpiPmi      ACPI Power Meter Drive Kernel        30/10/2015 02:42:47
acpitime     ACPI Wake Alarm Driver Kernel        30/10/2015 02:42:21
ADP80XX      ADP80XX                Kernel        09/04/2015 21:49:48
AFD          Ancillary Function Dri Kernel        05/11/2015 09:28:03
agp440       Intel AGP Bus Filter   Kernel        30/10/2015 02:39:51
ahcache      Application Compatibil Kernel        30/10/2015 02:09:45
AmdK8        AMD K8 Processor Drive Kernel        30/10/2015 02:09:49
AmdPPM       AMD Processor Driver   Kernel        30/10/2015 02:09:48
amdsata      amdsata                Kernel        14/05/2015 13:14:52
amdsbs       amdsbs                 Kernel        11/12/2012 21:21:44
```

> Laptop users might want to try **/batteryreport**, which gives you a full overview of your battery's health.

management tool is **powercfg /h**, which enables you to both disable and enable the hibernation function—disabling this is worth doing if you don't use it, because you can free up a fair amount of hard drive space (the equivalent of however much RAM is in your PC).

Powercfg offers you some useful information, too—use the **/energy** flag to generate a report that highlights energy efficiency and battery life issues that your PC may be suffering from. Once created, a file called energy-report.html is saved to the directory you're currently in. Before analyzing it to find out why your PC won't stay asleep, however, try **powercfg /lastwake**, which reveals the last device to wake your computer. Laptop users might want to try **/batteryreport**, which, like **/energy**, saves a report you can view in your web browser. This gives you a full overview of your battery's health, as well as a handy graph showing its usage over the past 72 hours.

And there's more

We've only really scratched the surface of what you can do with the Command Prompt so far—there's still plenty more you can investigate. So, let's start with the powerful—but potentially devastating—**diskpart** tool. Type **diskpart** and hit Enter, and you're either prompted to open a new window with administrator access, or the cursor changes to "DISKPART>." Type **help** for a list of supported commands, many of which are potentially destructive—whatever you do, don't proceed further without having a full system image backup in place for all your drives, just in case. Safe commands include **list disk** (list physical drives) and **list partition**, which works on the currently selected drive—switch drives using the **select disk <no>** command. Use **list volume** to view a list of drives by letter. When you've finished with **diskpart**, type **exit** and hit Enter to return to the main Command Prompt.

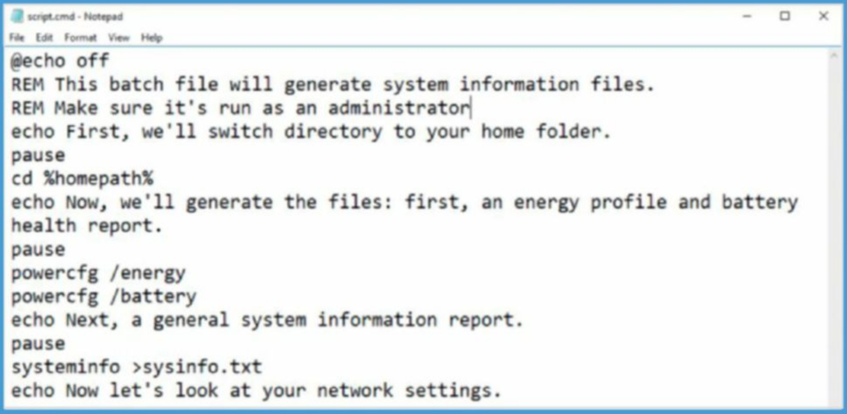
Want to securely erase some data? The **cipher** command enables you to wipe the free space in a folder by writing random data to it—delete your files first, then navigate to the folder in question, and type **cipher /w:<path>**, replacing **<path>** with the path to the folder that you wish to clean up. The **cipher** tool can also be used—as its name implies—to encrypt and decrypt files, too.

You can find out more about specific file types and their associated programs using the **assoc** and **ftype** commands, and use **bootcfg** to edit the boot.ini file (as viewed under the msconfig "Boot" tab). Want to compare the contents of two files? Simply use **fc** to compare your files and list their differences in text. If you want to compare word processing documents, such as those created in Microsoft Word, you need to use the **/l** flag to ensure that only the ASCII text is compared.

Other commands exist that may have value when unable to boot directly into the Windows desktop, but on the whole you're better off using Windows' own graphical-friendly tools. Examples include **at** (schedule commands and programs to run on a specified computer, at a set time and date), **sc** (display and configure Windows Services), **set** (set Windows environmental variables), and both **tasklist** and **taskkill**, which are a pair of commands that enable you to view running processes and terminate them.

There are many more commands to learn and master as well—you can find a complete list at https://technet.microsoft.com/en-us/library/bb490890.aspx—but here's one final useful command that can come in handy. Need to reboot your PC to the Advanced Start Options menu for a spot of troubleshooting? Just open Command Prompt, type **shutdown /r /o**, and hit Enter. You're welcome! ⏻

Working with Batch Files



```
@echo off
REM This batch file will generate system information files.
REM Make sure it's run as an administrator
echo First, we'll switch directory to your home folder.
pause
cd %homepath%
echo Now, we'll generate the files: first, an energy profile and battery
health report.
pause
powercfg /energy
powercfg /battery
echo Next, a general system information report.
pause
systeminfo >sysinfo.txt
echo Now let's look at your network settings.
```

Batch files are specially created text files that contain a list of Command Prompt commands, which are executed in the order they're written. They can also be used to call executable programs (use the **start** command), and are a great way to make repetitive commands easy to process.

You can create and edit batch files in Notepad—place each command with its options on a separate line. When you come to save the file, set "Save as type:" to "All Files (*.*)," before giving the file a .cmd extension.

There's a number of commands designed for use in batch files. One of the easiest to use is the **pause** command. Place this in your batch file, and when it's reached, the Command Prompt throws up a "Press any key to continue" message, and waits for a key to be pressed. You can also make use of the **echo** command to display text on-screen, and insert an **@echo off** command at the top of your batch file to prevent the commands themselves from appearing in the Command Prompt window as they're run.

Other useful commands include **call**, which enables you to call a second batch file from within the first, plus **choice** and **set** for introducing interactivity through the form of choices for the end user (you can also introduce conditions through the **if** and **goto** commands). Batch files can be run from within the Command Prompt window (you can drag them from File Explorer into the window), or simply by double-clicking them in File Explorer—you'll see the Command Prompt window appear, and it disappears when the script completes. Visit https://technet.microsoft.com/library/bb490869.aspx for a handy reference guide.

Your essential guide to competitive gaming

PC GAMER

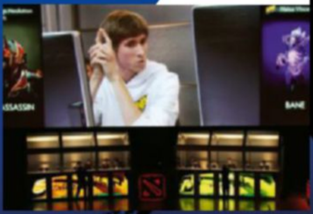
PRO

UP YOUR GAME

EVENTS

DON'T MISS A SINGLE **AMAZING MOMENT**

PEOPLE



LEARN FROM THE **VERY BEST**

GAMES

GET MORE FROM YOUR **FAVORITE GAMES**

MORE!

NEW FEATURES AND GUIDES **EVERY DAY**

GET STARTED AT

→ www.pcgamer.com/pro

LAUNCH PARTNERS

AVerMedia logitech G HYPERX

SUBSCRIBE TO MAXIMUMPC

THE GO-TO RESOURCE FOR PC ENTHUSIASTS...

CHOOSE YOUR PERFECT PACKAGE

1

THE DIGITAL EDITION

ONLY $9.00

EVERY YEAR

Instant digital access on your iPad, iPhone, and Android device.

2

THE PRINT EDITION

ONLY $24.00

EVERY YEAR

Every issue delivered to your door at a fraction of the cost.

3
COMPLETE PRINT
& DIGITAL BUNDLE
ONLY $28.00
EVERY YEAR

Get the print edition of *Maximum PC* delivered direct to your door, and instant access on your iPad, iPhone, or Android device.

MAXIMUM PC
TAKE FULL CONTROL OF WINDOWS
35 tips and tricks for an awesome PC!
MAXIMUM PC
BUILD IT! NEXT-GEN PC
60fps at 4K
10-core CPU
13TB of storage!
VR FACE-OFF
Oculus Rift vs. HTC Vive

On iOS & Android!

ONE EASY WAY TO SUBSCRIBE ONLINE...

http://bit.ly/MaximumPCSubs

TERMS AND CONDITIONS Savings compared to buying 13 full-priced issues from US newsstand. This offer is for new US subscribers only. You will receive 13 issues in a year. If you are dissatisfied in any way, you can write to us to cancel your subscription at any time and we will refund you for all unmailed issues. Prices correct at point of print and subject to change. For full terms and conditions, please visit http://bit.ly/magtandc. **Offer ends: July 26, 2016**

Ubuntu 16.04

As the Ubuntu release bandwagon rolls into town, *Mayank Sharma* helps you look past the fanfare

Install it! Get going in 4 mins on pg. 52

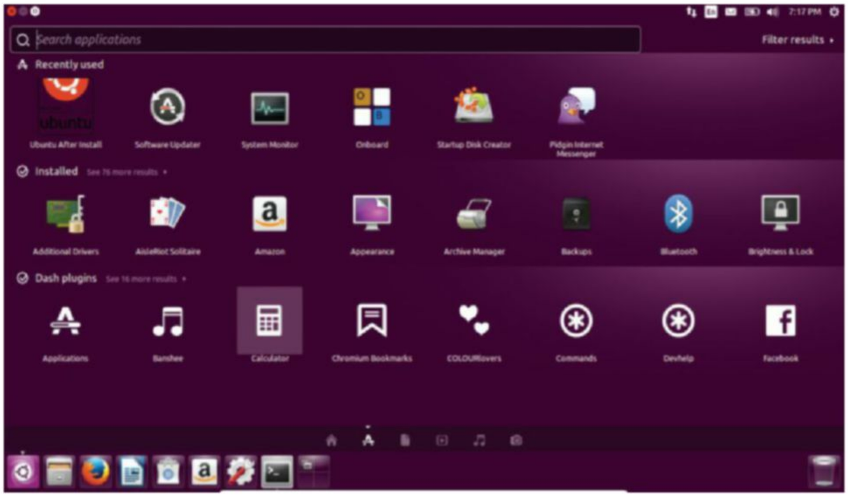
Every six months, the Ubuntu developers and ardent community of users and fans celebrate the arrival of a new release with almost religious fervor. The hoopla around the Ubuntu 16.04 LTS release is no different, except for the fact that this one ushers in enough changes to actually do justice to the adulation.

The Ubuntu distribution (distro) is on the cusp of introducing a major overhaul, with lots of changes to the back-end infrastructure that will have a direct bearing on the rendition of the desktop. The primary thrust behind the makeover is Canonical's aspirations to take the project beyond the desktop. If you recall the "successful failure" of the Ubuntu Edge Kickstarter campaign—which demonstrated that Canonical had been toying with the idea for years—it came to fruition with the launch of Ubuntu-powered phones in 2015.

New and Noteworthy

A look at some of the best features of the new release

An Ubuntu LTS release is always a special affair. The primary goal of the Ubuntu developers is to provide a stable platform that can run reliably for the duration of the extended support cycle. On top of that, they must also take into account future developments in the larger open-source software ecosystem that might have a direct bearing on their support infrastructure. For instance, Ubuntu 16.04 doesn't support AMD's proprietary fglrx drivers any more, because AMD has announced plans to wean users away from those drivers and toward the open-source amdgpu drivers.



You can now place the launcher at the bottom of the screen. Hallelujah!

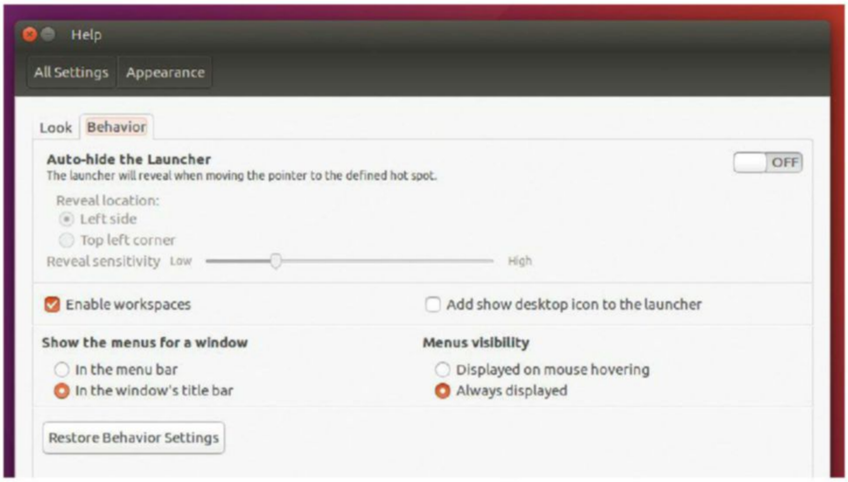
Last the term

Ubuntu 16.04 is a Long Term Support (LTS) release that will be supported until 2021. Unlike traditional Ubuntu releases, LTS releases come out every two years and continue to receive updates for the next five years. The LTS releases are prepared with more care than regular releases, and only include components that have been well tested by the Ubuntu developers or the larger community of Linux users. The regular Ubuntu releases have already switched to the Systemd service manager, and 16.04 will be the first LTS release to do so as well.

The distro is powered by Linux kernel 4.4, which is also an LTS release that will be supported for two years. This kernel makes significant strides toward supporting Intel's new Skylake family of processors, as well as ARM's 64-bit processors. Thanks to the addition of 3D support in the kernel's virtual GPU driver, which enables virtualization guests to use the host graphics card efficiently, you'll be able to run graphics-intensive applications inside a virtualized Ubuntu 16.04 installation, too.

Talking of graphics drivers, as mentioned earlier, the fglrx driver is now depreciated in the 16.04 release. The developers have backported code from Linux kernel 4.5 to provide a better experience using the much-improved open-source alternatives, namely radeon and amdgpu. If you use AMD graphics cards, note that not only will the upgrade process remove the proprietary drivers, but you also won't be able to manually install them after moving to Ubuntu 16.04. This is because the distro ships with Xorg 1.18, which doesn't support the AMD proprietary drivers.

Another feature in the 4.4 kernel that may have a significant effect during 16.04's support cycle is the kernel's ability to deliver updates through a standardized procedure. Coupled with Gnome's fwupd tool, currently under development, you could update your BIOS/UEFI firmware easily using Ubuntu's package management tools.



Auto-hide the Launcher OFF

The launcher will reveal when moving the pointer to the defined hot spot.

Reveal location:

● Left side

○ Top left corner

Reveal sensitivity Low High

☑ Enable workspaces

☐ Add show desktop icon to the launcher

Show the menus for a window

○ In the menu bar

● In the window's title bar

Menus visibility

○ Displayed on mouse hovering

● Always displayed

Restore Behavior Settings

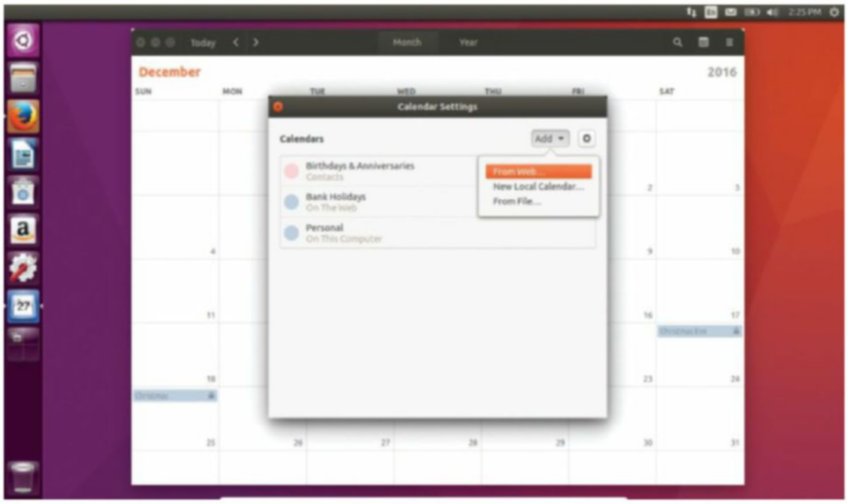
By default, Ubuntu only displays menus when you hover over the menu bar or a window's title bar. This behavior can now be tweaked from "System Settings → Appearance → Behavior."

Solid foundations

One of the major additions is support for the ZFS filesystem. It was available as a technology preview in the last Ubuntu 15.10 release; however, starting with 16.04, the filesystem is supported officially by an OpenZFS-based implementation (which will be controversial in some quarters, due to licensing issues). The ZFS filesystem is a popular and much sought-after filesystem by system admins, for implementation in situations where data integrity and resilience are paramount. The filesystem is the default on distros used for building data silos, such as FreeNAS. While ext4 remains the default filesystem of the distro, Canonical is hailing ZFS and the filesystem for hosting containers in Ubuntu 16.04, thanks to its data-crunching features.

On the desktop side of things, Ubuntu 16.04 ships with the Unity 7.4 desktop environment, as the new Unity 8 isn't quite ready. While the overall look for the Unity interface hasn't changed much, the desktop has had numerous minute improvements that help make it rock solid and very usable.

The Unity desktop now adds session shortcuts for logout, restart, and shutdown options in the Unity Dash, which also features new scroll bars. There are several other small usability improvements as well, such as the icons for external storage and "Trash" windows indicating the number



You can pull in and sync calendars to Gnome Calendar from many sources.

of open windows, just like any other icon on the Launcher. Furthermore, Unity will no longer wait for a resource-intensive application to load completely before it places an icon in the Launcher. If you use multiple workspaces and enable the Workspace Switcher, you can now right-click it to access a new Quicklist menu. The Quicklist options for removable drives now sport the option to format the device. Also, if you have a microphone connected, you can use the Sound menu to adjust its input volume with a slider.

After repeated requests from users, the previous version of Unity enabled you to show the menus for a window in the window's title bar, instead of the menu bar. In Unity 7.4, users can choose to display this menu automatically, instead of the earlier option, which displayed the menu only when you hovered the mouse over the area.

There's further evidence of the Ubuntu developers paying heed to their users' feedback (read: criticism). The project has received much flak for including the Amazon scope, which passed all user queries from the Dash to the ecommerce website, to bring up relevant results beside the applications and documents you were looking for. Ubuntu had earlier implemented a kill switch to disable this much-panned privacy-invading feature, and has now finally decided to disable it by default in the latest release.

Another change that took over six years to implement, which is a major departure from Ubuntu's adamant position of governing the usability of the Unity desktop, is the option to move the Unity Launcher to the bottom of the screen. This placement will be default on Ubuntu Kylin (the official Chinese rendition of the distro, who did all the heavy lifting to implement this feature). To move the Launcher on the main Ubuntu release, install the dconf-editor and navigate to "Com → Canonical → Unity → Launcher → Launcher-position."

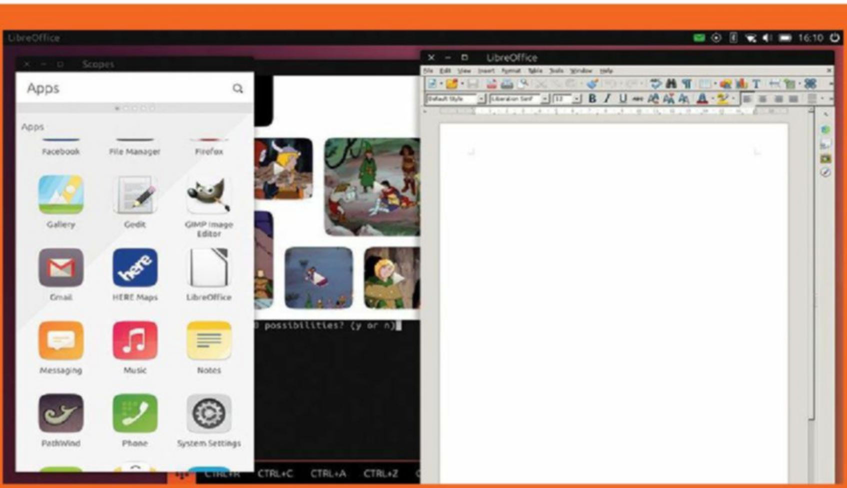
Talking of fixing long-standing issues, the onscreen keyboard in Ubuntu brings up a virtual keyboard that floats around the desktop. That's changed in Ubuntu 16.04, with the developers making the application pin a keyboard across the full width, at the bottom. This implementation looks more polished and refined.

Application swap

One thing that has been quite consistent between Ubuntu releases is its default set of apps. The distro has been quite usable straight out of the box, and the developers haven't heard enough noise from the community to alter its winning combination

While Ubuntu ships with some of the best and widely used open-source applications that are maintained and updated regularly,

Experience Unity 8



```
possibilities? (y or n)
```

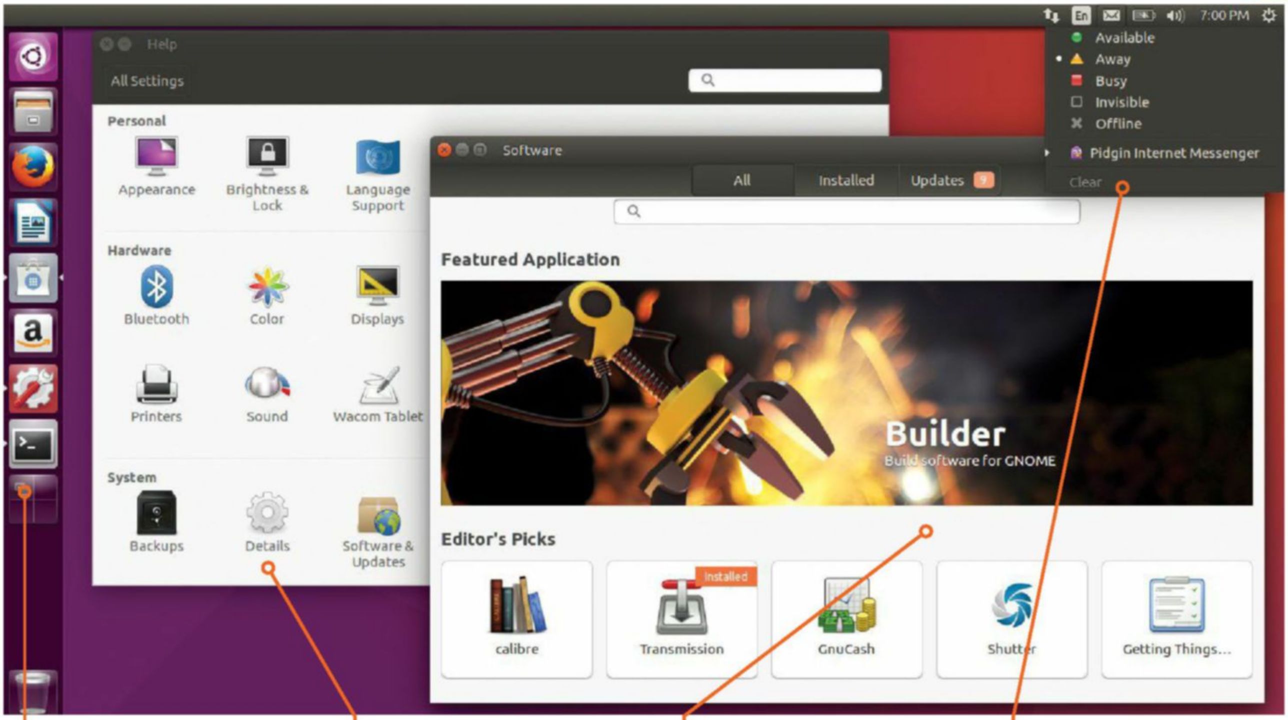
While Ubuntu 16.04 ships with an updated Unity 7 desktop environment, everyone's keeping their eyes peeled for Unity 8. This upcoming desktop environment is key to Canonical's convergence experience, and is based on Qt5/QML, unlike the previous versions, which were written in Ubuntu's own custom OpenGL-based toolkit, Nux.

The developers attribute this change to the positive experience with Qt5/QML while working on the Ubuntu Touch project. The other major change is the use of a totally new display server, as well. To achieve the user experience they want, the developers will implement Unity 8 on top of the Mir display server, instead of the traditional X window server system.

On the visual side of things, the Unity 8 user experience won't be all that different from the current Unity 7, but you can be sure of noticeable visual differences. In the overall scheme of things, Unity will still be a shell, with all its hallmark components, including a launcher, the indicators, and the Dash. But these will be enhanced and styled with improvements garnered from the Ubuntu Touch project.

Work on Unity 8 is nearing completion, but the desktop is still currently under active development, and isn't quite yet ready for the mainstream. However, here's a simple and safe way to experience the upcoming desktop on top of Ubuntu 16.04, brought to you by the miracles of Linux containers. Fire up a terminal window and type "sudo apt install unity8-lxc." When it's downloaded and installed, configure the container with "sudo unity8-lxf-setup." This command will take some time to complete as it configures the containers and downloads, and installs the Unity 8 meta-package, apps, and relevant dependencies. When it's done, reboot your computer, and then select the Unity 8 sessions from the login screen to experience Ubuntu's new desktop.

Navigating the Interface


7:00 PM
En
Available
Away
Busy
Invisible
Offline
Pidgin Internet Messenger
Clear
Help
All Settings
Personal
Appearance
Brightness & Lock
Language Support
Hardware
Bluetooth
Color
Displays
Printers
Sound
Wacom Tablet
System
Backups
Details
Software & Updates
Software
All
Installed
Updates
Featured Application
Builder
Build software for GNOME
Editor's Picks
calibre
Installed
Transmission
GnuCash
Shutter
Getting Things...

1 The Launcher

You can use the Launcher to begin exploring the distro. The first icon brings up the Dash, which displays a list of applications and other information depending on the enabled scopes and lenses. You can pin your favorite applications to the Launcher.

2 System Settings

You can configure all aspects of the Ubuntu 16.04 LTS desktop environment from this "System Settings" window. Use the gears-and-spanner icon pinned to the Launcher to bring it up. The window is logically arranged, and is fairly intuitive to navigate around and use.

3 Gnome Software

Starting with Ubuntu 16.04 LTS, the distro will use the Gnome Software package manager. You can use the manager to search for and install any applications from the Ubuntu repositories (repos). Like all good app stores, Gnome Software lets you rate and review apps.

4 Messaging Menu

If you have installed an instant messenger, such as Pidgin, you can use the envelope icon in the menu bar to bring up the Messaging menu. This menu helps you keep track of all your IM accounts, and enables you to change your availability across them all.

two haven't received developer attention for quite a while: Empathy and Brasero. Both of these applications have been zapped from the official ISO image of the distro. While they are no longer available in the default installation, you can still easily fetch them from the official repos.

Of the two, Empathy was pivotal to one of Unity's key components: the Messaging menu. With Empathy no longer installed, the icon for the feature is missing from the top-right corner of the menu bar. Also, the Online Accounts feature will no longer allow you to add accounts on instant messaging services and XMPP servers. However, you can bring back the Messaging menu by installing either Empathy or the much more actively maintained instant messaging application, Pidgin, which ships with the Unity Integration plugin, enabled by default to hook up with the desktop environment.

The one major application to be dropped from the 16.04 release is Ubuntu's marquee Software Center. Like the other applications, it didn't receive much love from its developers (Canonical itself), beside the one-off patch for fixing vulnerabilities. This, coupled with rumors of a new improved software center for Unity 8, led the Ubuntu Mate spin to drop the Ubuntu Software Center from its distro. With the 16.04 release, Canonical has validated the move by dropping it from the main release, as well. Instead, the distro has switched to the actively maintained Gnome Software, which is steadily picking up new features.

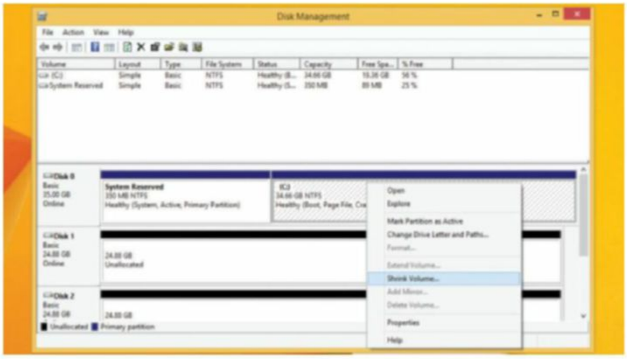
In more packaging-related news, the Ubuntu developers have also reworked the mechanism for labeling dependencies behind the scenes. Several dependencies have been moved to the "Recommends" section, instead of their original "Requires" position. The result of this change is that you'll be able to remove particular applications from your installation without breaking the desktop—for example, you'll be able to remove LibreOffice without removing the Ubuntu Meta package along with it as well. The change is meant to allow users more control over what packages are on their desktop.

Another application that Ubuntu has picked up from the Gnome project is Gnome Calendar, which is more feature-rich and integrates well with the Ubuntu desktop. Gnome's calendar app was chosen over Ubuntu's own because it strikes the right balance between offering more features and usability—for example, the application can visualize your upcoming events in several different ways, and it enables you to search the calendar, too.

Phew—that's quite a lot of changes for an LTS release. If you were waiting for the right release to come along before plunging head first into Ubuntu, this is it. Follow our installation guide on the next page, and drape your computer in the Ubuntu (purplish) orange.

Manually Install Ubuntu

Resize your disks and dual-boot Windows with Ubuntu



Volume	Layout	Type	File System	Status	Capacity	Free Spa...	% Free
(C:)	Simple	Basic	NTFS	Healthy (B...	34.66 GB	19.36 GB	56 %
System Reserved	Simple	Basic	NTFS	Healthy (S...	350 MB	89 MB	25 %

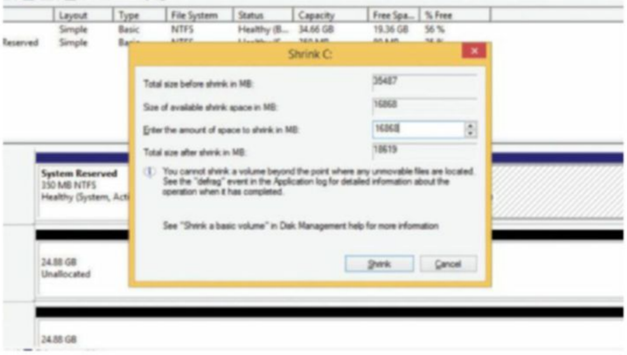
Disk 0 Basic 35.00 GB Online — System Reserved 350 MB NTFS Healthy (System, Active, Primary Partition); (C:) 34.66 GB NTFS Healthy (Boot, Page File, Cra

Disk 1 Basic 24.88 GB Online — 24.88 GB Unallocated

Disk 2 Basic 24.88 GB — 24.88 GB

1 Make Room

To create an empty partition for your Ubuntu installation, you'll first have to squeeze your existing Windows partition. Fire up the Disk Management tool in Windows, and right-click your main partition, which is typically assigned the drive letter C. Then select the "Shrink Volume" option from the pop-up menu.



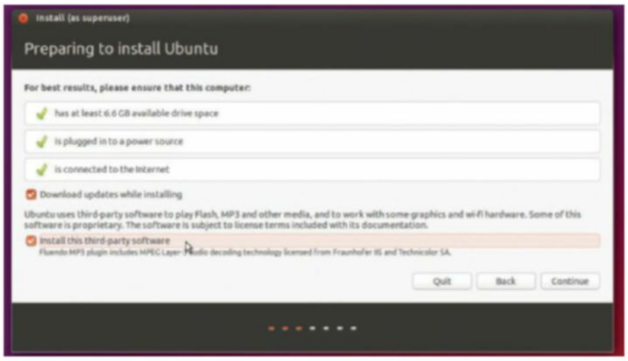
Total size before shrink in MB: 35487
Size of available shrink space in MB: 16868
Enter the amount of space to shrink in MB: 16868
Total size after shrink in MB: 18619

You cannot shrink a volume beyond the point where any unmovable files are located. See the "defrag" event in the Application log for detailed information about the operation when it has completed.

See "Shrink a basic volume" in Disk Management help for more information

2 Shrink Windows

This brings up the Shrink dialog box, which shows you the total size of the hard drive, and the maximum amount of space that you can squeeze out of the selected partition. To create a new partition, specify the size of the partition in megabytes in the space provided, and click "Shrink" to start the process.



Preparing to install Ubuntu

For best results, please ensure that this computer:

✓ has at least 6.6 GB available drive space

✓ is plugged in to a power source

✓ is connected to the Internet

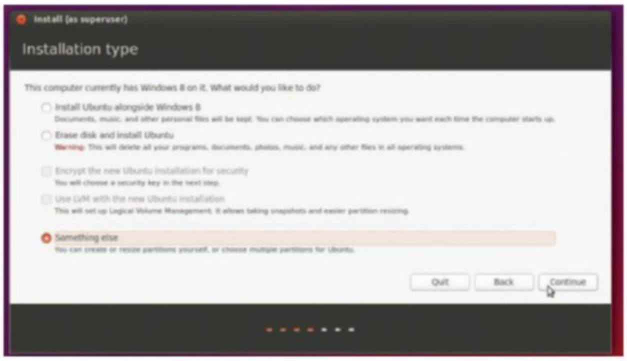
☑ Download updates while installing

Ubuntu uses third-party software to play Flash, MP3 and other media, and to work with some graphics and wi-fi hardware. Some of this software is proprietary. The software is subject to license terms included with its documentation.

☑ Install this third-party software
Fluendo MP3 plugin includes MPEG Layer-3 audio decoding technology licensed from Fraunhofer IIS and Technicolor SA.

3 Updates and Plugins

After your computer boots from the Ubuntu installation medium, it displays a checklist. Make sure you toggle the two available checkboxes on this screen. The first checkbox option fetches any available updates from the Internet, and the other installs the plugin required to play MP3 content.



Installation type

This computer currently has Windows 8 on it. What would you like to do?

○ Install Ubuntu alongside Windows 8
Documents, music, and other personal files will be kept. You can choose which operating system you want each time the computer starts up.

○ Erase disk and install Ubuntu
Warning: This will delete all your programs, documents, photos, music, and any other files in all operating systems.

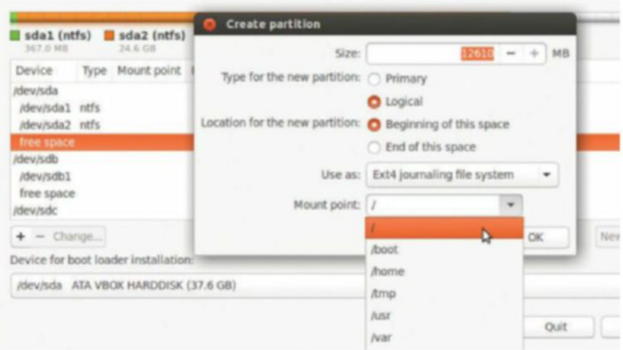
☐ Encrypt the new Ubuntu installation for security
You will choose a security key in the next step.

☐ Use LVM with the new Ubuntu installation
This will set up Logical Volume Management. It allows taking snapshots and easier partition resizing.

● Something else
You can create or resize partitions yourself, or choose multiple partitions for Ubuntu.

4 Use Free Space

In the screen labeled "Installation type," toggle the "Something else" radio button to manually partition the disk. Ubuntu now shows you a list of partitions on the hard drive. Select the one labeled "Free space," and click the plus sign ("+") to create a partition out of the space you freed up in Windows.



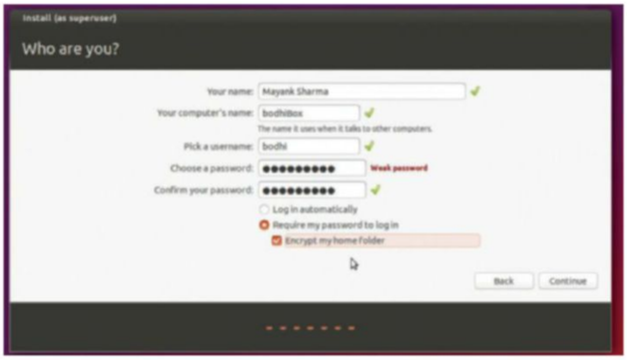
Device	Type	Mount point
/dev/sda		
/dev/sda1	ntfs	
/dev/sda2	ntfs	
free space		
/dev/sdb		
/dev/sdb1		
free space		
/dev/sdc		

Size: 12610 MB
Type for the new partition: ○ Primary ● Logical
Location for the new partition: ● Beginning of this space ○ End of this space
Use as: Ext4 journaling file system
Mount point: /

Device for boot loader installation:
/dev/sda ATA VBOX HARDDISK (37.6 GB)

5 Define Partitions

In the Create Partition box, enter the size for the Ubuntu partition, leaving 1,024MB free for the swap partition. Then use the Mount Point pull-down menu to select the "/" option. Similarly, create a partition for swap, but instead of the default "ext4" option, select the "Swap area" option.



Who are you?

Your name: Mayank Sharma ✓
Your computer's name: bodhiBox ✓
The name it uses when it talks to other computers.
Pick a username: bodhi ✓
Choose a password: ●●●●●●●●● Weak password
Confirm your password: ●●●●●●●●● ✓
○ Log in automatically
● Require my password to log in
☑ Encrypt my home folder

6 Login Credentials

And that's it. The installer now starts the process of installing Ubuntu. While the files are being copied to the hard drive in the background, it asks you for your location and time zone, as well as your keyboard layout. In the last screen, you're asked to enter your desired login and password details.

Post-Install Tweaks

Polish your freshly minted installation for maximum mileage

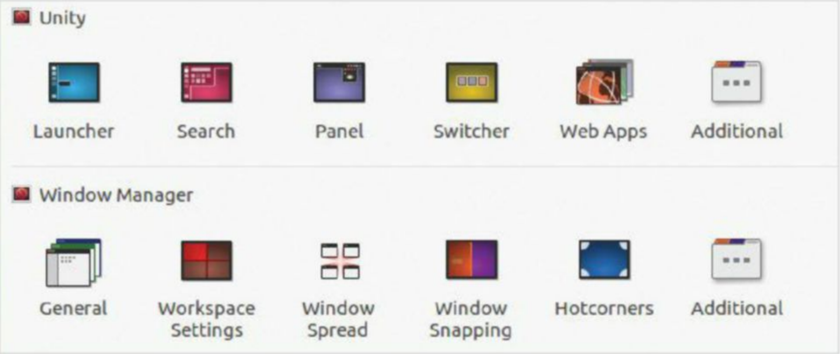
Fetch updates

The Ubuntu installer offers a checkbox to install updates during installation. Even if you toggle the checkbox, one of the first things you should do on a pristine installation is to check for available updates. Open the Dash, search for updates, and click the Software Updater launcher. Once it has scanned the Ubuntu repos for available updates, click the “Install Now” button to install any updates that are available.

Enable the firewall

A firewall helps insulate your computer from malicious users looking for ways to gain access to your system. Linux includes the comprehensive iptables firewall, which can be easily managed with the Gufw application. It’s available in Ubuntu’s Universe repos, and can be installed with “sudo apt-get install gufw.” Once installed, bring up the “System Settings” window, and click the “Firewall Configuration” option under the “System” section. Begin by first enabling the firewall.

Once enabled, you can set the incoming and outgoing policies by selecting one of the three options in the drop-down menus. The “Allow” option allows traffic without asking any questions. The “Deny” option silently discards all incoming or outgoing packets. The “Reject” option is different in that it sends an error packet to the sender of the incoming packets. After you’ve set the policy for traffic, you can define specific rules for individual apps and services. To create a rule, switch to the “Rules” tab, and click the “+” button. Use the “Preconfigured” tab to select the application, and Gufw defines the most effective rules.



Use the Ubuntu Tweak Tool to customize and mould various aspects of the Unity desktop.

Install proprietary drivers

Despite the improving quality of free software drivers, some of your computer’s hardware can only be used to its full extent via proprietary drivers. This is particularly true for gaming with the latest generation of graphics cards. By default, Ubuntu only ships with and uses open-source drivers, but you can install proprietary ones with ease. Head to the Dash, type “software,” and open the Software & Updates tool. Then switch to the “Additional Drivers” tab, which scans your computer and lists the drivers that best suit your proprietary hardware.

Configure backups

Ubuntu ships with one of the simplest-to-use backup tools, called Déjà Dup. The application has a very minimal interface, but you need to configure it before putting it into action. Bring up the “System Settings” window, and click the “Backups” option under the “System” section to launch Déjà Dup. Switch to the “Folders to Save” tab, and use the “+”button at the bottom to point the app to the folder you wish to save. After you’ve selected the folders to back up, switch to the “Storage Location” tab to point the tool to where you want to house your backups.

On larger tablets, you can switch to Desktop mode, with apps running inside windows.

Déja Dup can save your backups on a separate partition or in a remote location, accessible via SSH, FTP, Samba, or WebDAV. While creating a backup, Déja Dup also, optionally, allows you to encrypt backups. Creating the initial backup usually takes quite some time, but subsequent backups are much faster, because the tool only backs up data that has changed.

Install essential applications

While Ubuntu ships with all the package management tools at your disposal, you can save yourself some time and use the Ubuntu After Install (UAI) application to do the heavy lifting for you. This can install dozens of essential applications in a single click. Some applications that it can install are not available in the Ubuntu repos, and require the addition of a PPA. Here, too, UAI can save you time and effort, and install the PPAs automatically. To use UAI, scroll down its homepage (http://bit.ly/UAIHowTo), and install the Deb using Gnome Software. Once installed, launch the application from the Dash, and select what you wish to install, before hitting the “Install Now” button.

Set up online accounts

Ubuntu can pull in content from several popular (albeit mostly proprietary) services, right to your desktop. To get started, bring up the System Settings by clicking on the gears icon in the top-right corner, and head to the “Online Accounts” option. Use the interface to add your accounts on any of the supported services. After you’ve added an account, Ubuntu enables you to search for content on these online services from the Dash. You’ll also be able to publish content from the associated application—for example, you can post photos from Shotwell directly to a Flickr album.

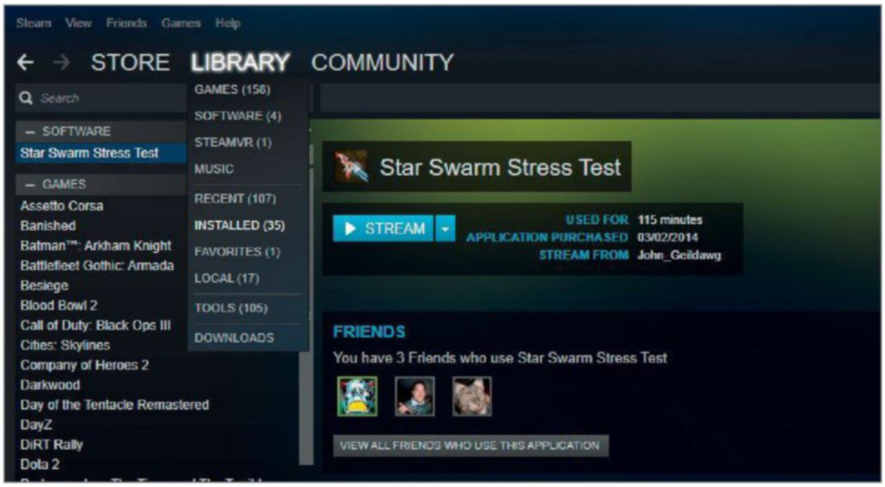
The home of technology

techradar.com

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

WINDOWS TIP OF THE MONTH



– SOFTWARE
Star Swarm Stress Test
– GAMES
Assetto Corsa
Banished
Batman™: Arkham Knight
Battlefleet Gothic: Armada
Besiege
Blood Bowl 2
Call of Duty: Black Ops III
Cities: Skylines
Company of Heroes 2
Darkwood
Day of the Tentacle Remastered
DayZ
DiRT Rally
Dota 2

Star Swarm Stress Test

USED FOR 115 minutes
APPLICATION PURCHASED 03/02/2014
STREAM FROM John_Geildawg

FRIENDS
You have 3 Friends who use Star Swarm Stress Test

TRAVERSING YOUR STEAM LIBRARY

Steam is the world's most popular digital game library, and with good reason: it's massive. The thing is, a lot of us have had accounts ever since Steam first started running, and our game libraries are hardly getting any smaller, especially with the likes of the Humble Bundle and other budget game packages absorbing our time. A nifty trick to traverse your Steam library quickly is to use the "Installed" drop-down option. Simply hover the mouse over "Library," then select "Installed."

MAKE – USE – CREATE

58
Create your own version of 2048 in Minecraft: Pi

62
Windows 10 installation problems fixed!

66
Build your own goliath gaming workhorse

ZAK STOREY
STAFF WRITER

BUYING THE "RIGHT" GPU

Choosing a graphics card is tricky. It's far too easy to fall into the trap of buying the best card you can get your hands on. Although it may future-proof you to some degree, it's often not the best way to buy if you're looking to keep your savings high.

When choosing a GPU, there are three things to take into account: what resolution and refresh rate you're going to run at; what games you play; and what you'll be doing in two or three years' time. It's all well and good buying three GTX 980 Tis, but if you're going to sit there gaming on a 1080p 60Hz screen, pawning noobs in the early hours of the morning in *League*, day in, day out, you've just dropped $1,000 on the equivalent of two-and-a-half power-hungry paperweights. In contrast, an overclocked GTX 950 will easily hit 100-plus fps in *League* at 1080p, giving you just as smooth a gaming experience on a 60Hz monitor as you'd get with those GTX 980 Tis.

Then there are those pesky product release schedules. It's advisable to wait at least three or four months after the initial release of a new graphics processor—early adopters pay the price as Nvidia and AMD revalue their cards within a couple of weeks of the competition launching its latest GPUs.

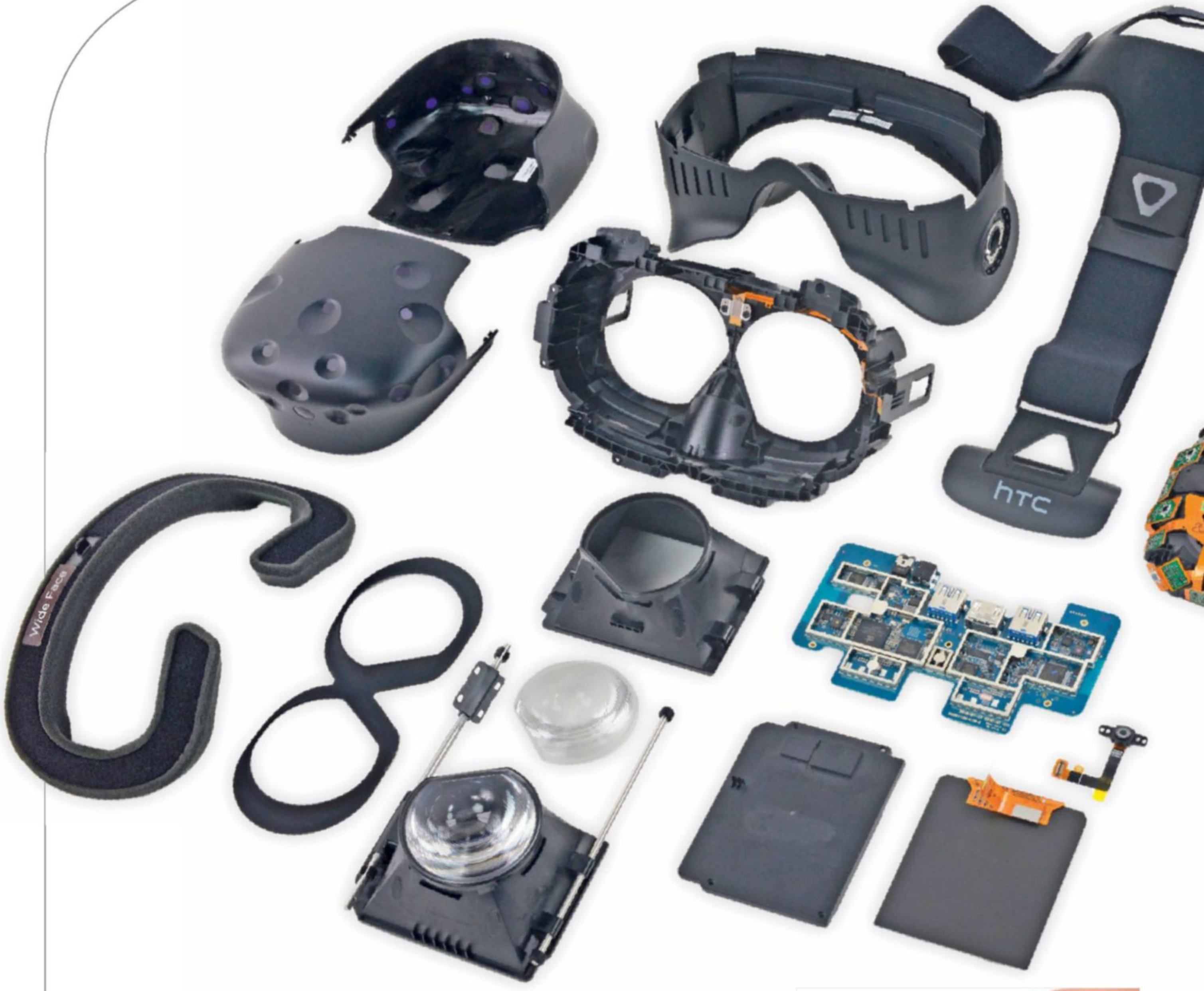
So, be patient, consider what you're purchasing, don't just go for the epeen factor, and you'll save yourself a bucket-load of cash, while still being able to game exactly how you want to.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT
presents:

AUTOPSY

THIS MONTH WE DISSECT...



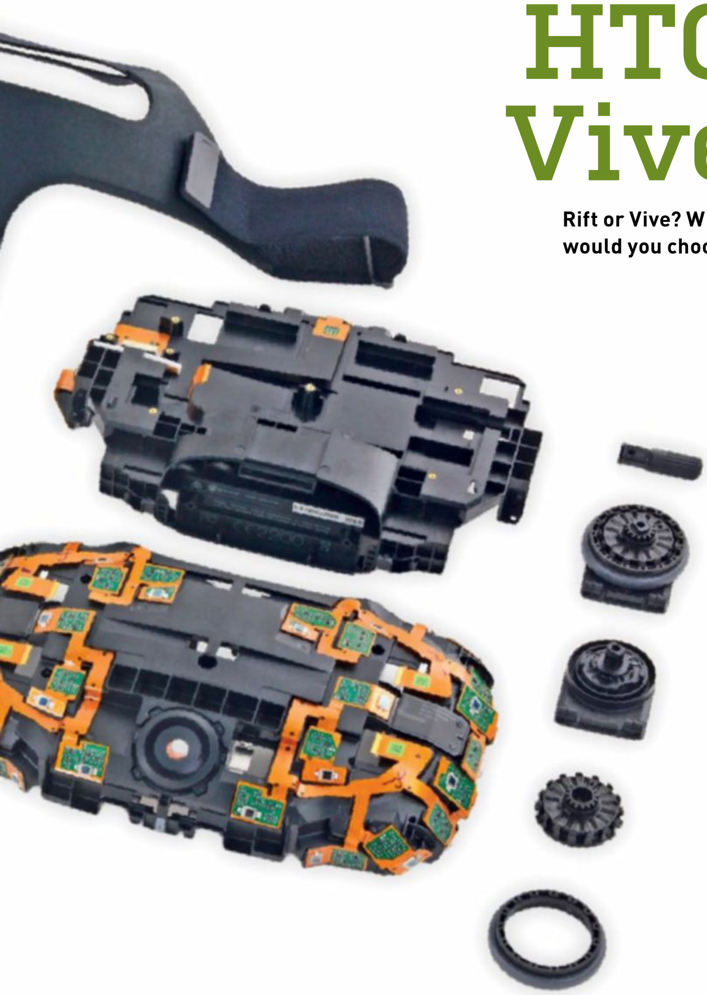
About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

These little Lighthouses will help you dance around your room with ease.

HTC Vive

Rift or Vive? Which would you choose?



Repurposed from the Steam Controller? Easy to fix, then.

BACKGROUND:

Around here, it's all about gadget guts. With VR becoming all the rage, we couldn't wait for a Vive-section. What does HTC have hiding before your eyes? Strap a black box to your head, cos we're about to find out! It's time to tear down the Vive.

MAJOR TECH SPECS:

- 2x 1080p AMOLED displays; 2160x1200 combined resolution
- 90Hz refresh rate
- Built-in front-facing camera and microphone
- Accelerometer, gyroscope, and laser position sensor
- 360-degree headset tracking via Lighthouse IR emitters
- 110-degree horizontal field of view

KEY FINDINGS:

- After unplugging the four headset cables, we spot a standard 3.5mm audio jack, DC barrel jack, and a single HDMI port, flanked by two USB 3.0 ports. Interestingly, HTC left the right-most USB port open for third-party accessories.
- Nestled between the eyepieces is a proximity sensor, which detects when the Vive is on your face—for power saving reasons. Cog-zooks! We've got our gears turning as we remove the eye-relief adjustment on the Vive headset; not to be confused with IPD, this controls the distance from the headset's optics to your eyes.
- Pulling back the outer shell on the Vive reveals a number of sensors—32 in total, according to HTC. These photodiodes take in IR light from the two Lighthouse base stations as they flash and sweep light across the room. This enables a connected PC to calculate the headset's position and orientation in space, as a function of the time between receiving the flash and the following IR laser sweep—the opposite of the head-tracking technique of the Oculus Rift.
- After removing four Phillips screws, we lift away the display cover for access to one of the twin Samsung AMOLED panels. Each display measures ~91.8 mm diagonally, which translates to ~447ppi. For comparison, the Rift CV1 has ~456ppi, due to a slightly smaller display (90 mm) that still packs the same resolution as the Vive. A bit of adhesive secures each lens, but it doesn't take much to pop them out.
- Repairability Score: 8 out of 10 (10 is easiest). Although it's a complicated bit of gear, the headset breaks down without damage. The head strap and face pads are removable, and don't incorporate sensors or electronics that might be prone to failure. Phillips and Torx screws are used throughout. Reuse of the touchpad hardware from the Steam Controller means some replacement parts are likely already available. The large number of components, many quite delicate, means you'll want a service manual before attempting repairs. Adhesive is used sparingly, but secures the lenses, Lighthouse base station covers, and sensor arrays.

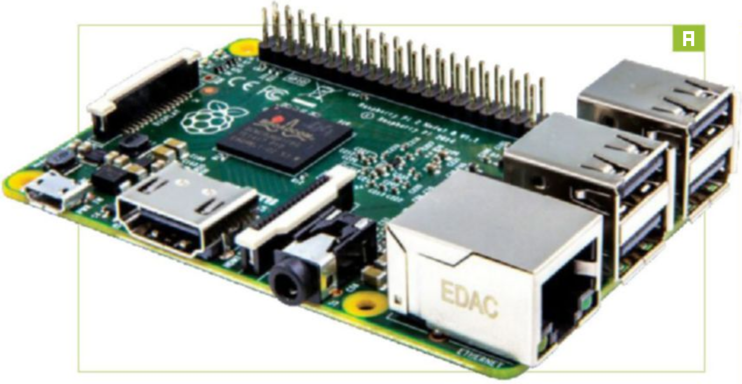
Python: Create 2048 in Minecraft

YOU'LL NEED THIS

RASPBERRY Pi 2
The brilliant mini-computer costs under $45. See www.raspberrypi.org.

MINECRAFT
Download the latest version from http://pi.minecraft.net.

IF YOU HAVEN'T YET EXPERIENCED the opium-like moreishness of the Android/iOS game *2048,* consider yourself lucky. Because, once you've had a taste of the thrilling addition of successive powers of two, you'll be addicted, and addicts, like so many hopeless lovers, are powerless to abandon the pursuit of the cherished 2048 tile, always just beyond reach. Granted, much of the pleasure comes from the touch interface—there is an innate pleasure in orchestrating an elegant and board-clearing sequence of cascades with just a few well-executed swipes—but, be that as it may, the game has simple rules and is based on blocks. As such, it's perfect material for the next installment in our *Minecraft: Pi Edition* programming series. If you haven't already run through last issue's *Minecraft* tutorial, do that before embarking on this project, because that gets your installation up and running so that Python and *Minecraft: Pi Edition* are configured to work together on your Raspberry Pi [Image A]. **–JONNI BIDWELL**



1 GET STARTED

We'll worry about how to draw and move the blocks later on. The first challenge is to understand the algorithm underlying the game, so dutifully read the rules in the box on page 61—they might seem clumsily worded or overly complex, but rest assured, they have been carefully crafted for easy translation to Python. Sometimes, it's easier to visualize the situation using pseudocode—this way, we can see the shape of the program without getting bogged down in details.

```
for each row:
  move tiles left, clearing empty space

for each row:
  for column 0 to 2:
     if tile[row,column + 1] = tile[row,column]:
        double tile[row, column]
        for x in column + 1 to 2:
           tile[row][x] = tile[row, x + 1]
        empty tile[row,3]

insert random 2 or 4 tile
if no move can be done:
  game over
```

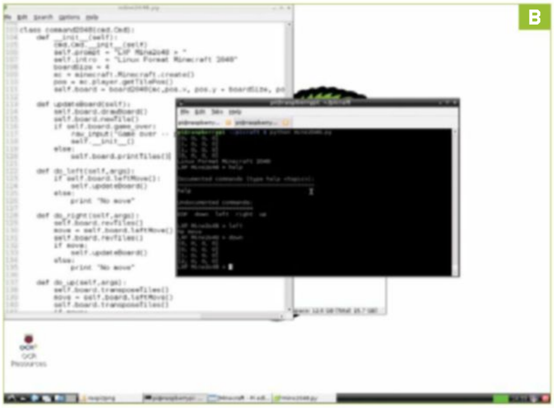
» Our task now is to flesh out the English bits of the above code, but to do this, we need to state how we're going to represent the board and tiles. This is done using a 4x4 array called "tiles." The first co-ordinate is the row number, and the second the column number, numbering the rows from top to bottom, and the columns from left to right. Python uses 0-based lists, so "tiles[0][0]" is the top-left tile. Non-empty tiles are all powers of 2, so we can use the exponent rather than the actual value here—for example, 32 is represented by 5. We can represent empty tiles using 0, so our array "tiles" is comprised entirely of (small) integers. Lovely.

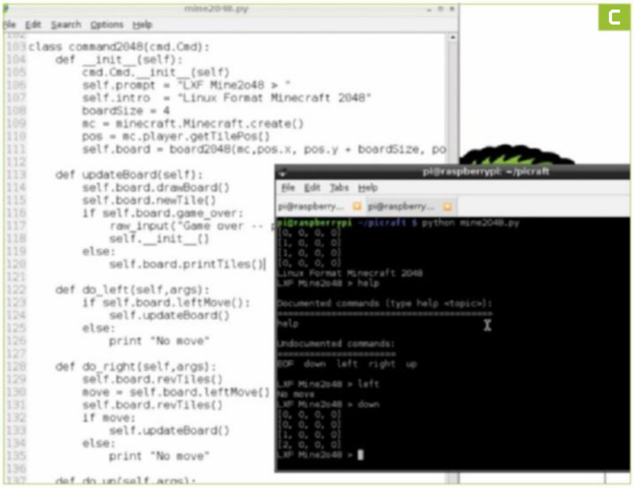
2 OBJECTIVE SNAKES

Now we know what we're dealing with, we can set about doing some actual Python coding. We've gone for an object-oriented approach here, which means that there will be a lot of "self" flying around—but don't worry, because it makes it easier for the *Minecraft* functions to talk to those to do with the board and the command interpreter. Honest.

» Let's look at line 2 of our pseudocode, in which we move tiles in the row left, occupying any available empty tiles. Python does have a "remove()" method for lists, but it only works on one element at a time, so we clear the zeroes from our row the old-fashioned way. We don't waste time fiddling with empty rows, and we also need to keep track of whether we actually moved anything (through the boolean "isMove"). Also, don't worry about the three other possible moves for now; we can cater for them later with a very cunning trick.

```
def leftMove(self):
```





C

```
class command2048(cmd.Cmd):
    def __init__(self):
        cmd.Cmd.__init__(self)
        self.prompt = "LXF Mine2048 > "
        self.intro  = "Linux Format Minecraft 2048"
        boardSize = 4
        mc = minecraft.Minecraft.create()
        pos = mc.player.getTilePos()
        self.board = board2048(mc,pos.x, pos.y + boardSize, po

    def updateBoard(self):
        self.board.drawBoard()
        self.board.newTile()
        if self.board.game_over:
            raw_input("Game over -- 
            self.__init__()
        else:
            self.board.printTiles()

    def do_left(self,args):
        if self.board.leftMove():
            self.updateBoard()
        else:
            print "No move"

    def do_right(self,args):
        self.board.revTiles()
        move = self.board.leftMove()
        self.board.revTiles()
        if move:
            self.updateBoard()
        else:
            print "No move"

    def do_up(self,args):
```

```
pi@raspberrypi ~/picraft $ python mine2048.py
[0, 0, 0, 0]
[1, 0, 0, 0]
[1, 0, 0, 0]
[0, 0, 0, 0]
Linux Format Minecraft 2048
LXF Mine2048 > help

Documented commands (type help <topic>):
========================================
help

Undocumented commands:
======================
EOF  down  left  right  up

LXF Mine2048 > left
No move
LXF Mine2048 > down
[0, 0, 0, 0]
[0, 0, 0, 0]
[1, 0, 0, 0]
[2, 0, 0, 0]
LXF Mine2048 > 
```

```
isMove = False
for row in range(self.boardSize):
    j = 0
    while j < self.boardSize - 1:
        # check rest of row non-empty
        row_empty = True
        for k in range(j,self.boardSize):
            if self.tiles[row][k] != 0:
                row_empty = False
        if self.tiles[row][j] == 0 and not row_empty:
            for k in range(j,self.boardSize - 1):
                self.tiles[row][k] = self.tiles[row][k + 1]
            self.tiles[row][self.boardSize - 1] = 0
            isMove = True
        else:
            j += 1
```

›› Now we can deal with the second psuedocode block, finding two horizontally-adjacent tiles that are the same.

```
for row in range(self.boardSize):
    for column in range(self.boardSize - 1):
        if self.tiles[row][column] == self.tiles[row][column + 1] \
        and self.tiles[row][column] != 0:
            self.tiles[row][column] += 1
            for k in range(column + 1, self.boardSize - 1):
                self.tiles[row][k]= self.tiles[row][k + 1]
            self.tiles[row][self.boardSize - 1] = 0
            isMove = True
return isMove
```

3 GAME OVER?

Things turn out to be simpler if we split off the third pseudocode block into its own function, "newTile()." We first need a list of co-ordinates of all the empty tiles; if there's more than one, it's certainly not Game Over, but even if there's only a single space (which will get filled by a new tile), there still may be possible moves. We use a couple of functions from the "random" module to help decide the where and what is of the new tile.

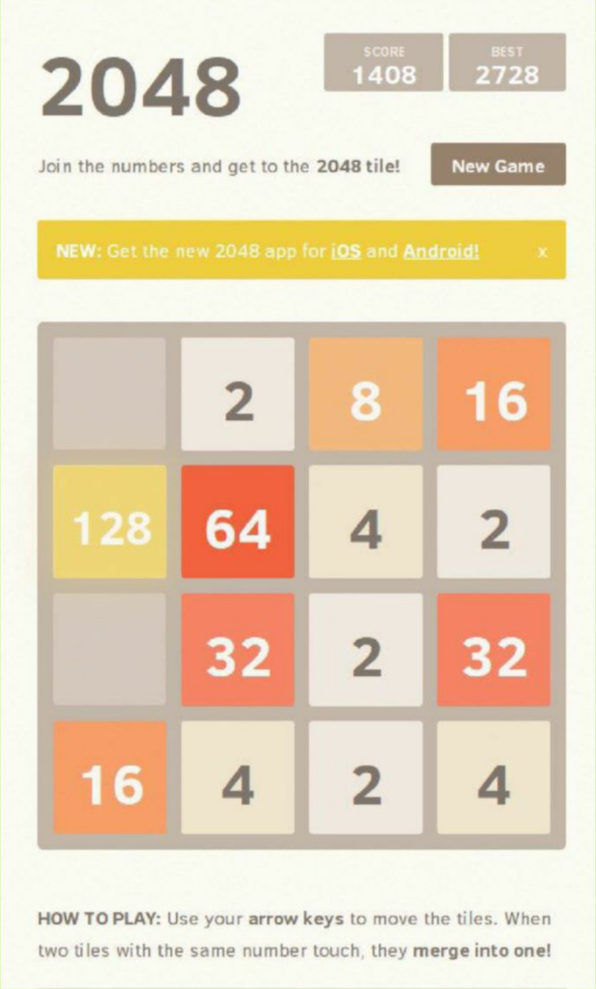
```
def newTile(self):
    empties = []
    self.game_over = True
    for j in range(self.boardSize):
        for k in range(self.boardSize):
            if self.tiles[j][k] == 0:
                empties.append([j,k])

    if len(empties) > 1:
```

2048: AN OPEN SOURCE ODYSSEY

The *2048* game was written by young Italian programmer Gabriele Cirulli, who wanted to see whether he could write a game in a weekend. The fruits of his labor proved hugely popular, accruing some four million downloads within a week of its release in March 2014. Numbers soared after mobile versions were released the following May, with up to 50,000 simultaneous players at its peak.

The game is described as a clone of Veewo Studio's *1024*, and conceptually similar to the indie title *Threes!* Rather than profit from his success, Cirulli's blog says he "didn't feel good about keeping [the code] private, since it was heavily based off someone else's work." Thus it is available to all at https://github.com/gabrielecirulli/2048. In the spirit of open source, this spurred all kinds of additions and modifications, and further depleted global productivity. We've played versions where the numbers are replaced with characters from *The Simpsons*, *Star Wars*, and *Harry Potter*, to name but a few. Regardless of the images, it's the same basic code underneath.



Join the numbers and get to the **2048 tile!**

NEW: Get the new 2048 app for iOS and Android!

	2	8	16
128	64	4	2
	32	2	32
16	4	2	4

HOW TO PLAY: Use your **arrow keys** to move the tiles. When two tiles with the same number touch, they **merge into one!**

```
    self.game_over = False

  rnd_pos = random.choice(empties)
  rnd_n = random.randint(1,2)
  self.tiles[rnd_pos[0]][rnd_pos[1]] = rnd_n
  self.drawBoard()
```

» The "drawBoard()" function is what actually places the blocks in *Minecraft* world. Checking whether moves are possible after the tile is added is a little awkward:

```
  # check row neighbors
  for j in range(self.boardSize):
    for k in range(self.boardSize - 1):
      if self.tiles[j][k] == self.tiles[j][k + 1]:
        self.game_over = False

  # check col neighbors
  for j in range(self.boardSize):
    for k in range(self.boardSize - 1):
      if self.tiles[k][j] == self.tiles[k + 1][j]:
        self.game_over = False
```

» Amazingly, that's the guts of the code all dealt with, but we still need a means by which to input our moves—and, of course, we need to render the results in *Minecraft*.

ANOTHER PI TUTORIAL NEXT MONTH

4 MASTER AND COMMANDER

We use the "cmd" module to provide a simple command-line interface to our game; all the code is available from www.pastebin.com/5zEZUfBS. We shall have a command for initializing the board, four directional commands, and a command to quit, Ctrl-D, aka the end of file (EOF) character, or the quick way to end a Python session. We even get a help command for free [**Image B**]. When you enter a command—"left," for example—the "cmd" module runs the function with that name prefixed by "do_" hence we have a function "do_left()" which calls the "leftMove()" function above. This function is really part of our board class.

» The "do_left()" function checks if the left move is valid and, if so, updates the board, via the imaginatively titled "updateBoard()" function, which in turn adds a new tile, and decides whether or not the game is up. If it is all over, we cheekily use "raw_input()" as a means to wait for the user to press Return.

» The "cmd" module works by subclassing its "Cmd" class. Any class you write that instantiates this inherits all of its functionality. We use the standard boilerplate to start things up when the program is executed:

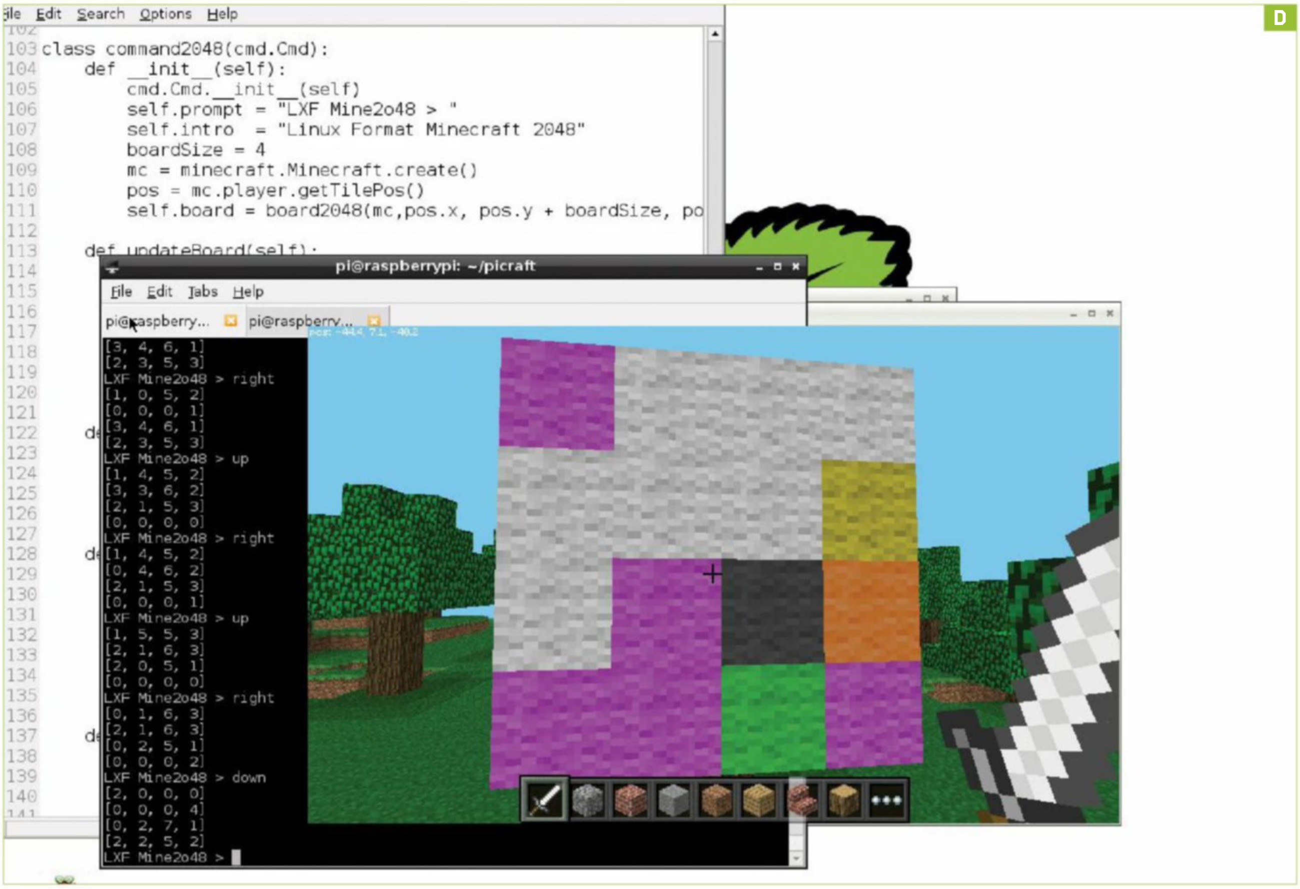
```
if __name__ == "__main__":
  command2048().cmdloop()
```

» This instantiates our command interpreter when the program is run with:

```
$ python mine2048.py
```

5 CLASSIC DEPENDENCIES

Minecraft must be running when you do this, or you run into errors. Also, you need to make sure you've copied the Python API from your *Minecraft* install (for example, "~/mcpi/api/python/mcpi") to a subdirectory called "minecraft" in the same directory as the "mine2048.py" file. If you've been following our *Minecraft* series, you'll be au fait with all this. The "command2048" class's "__init__()" method sets up the basics, including



D

```
class command2048(cmd.Cmd):
    def __init__(self):
        cmd.Cmd.__init__(self)
        self.prompt = "LXF Mine2o48 > "
        self.intro  = "Linux Format Minecraft 2048"
        boardSize = 4
        mc = minecraft.Minecraft.create()
        pos = mc.player.getTilePos()
        self.board = board2048(mc,pos.x, pos.y + boardSize, po

    def updateBoard(self):
```

```
[3, 4, 6, 1]
[2, 3, 5, 3]
LXF Mine2o48 > right
[1, 0, 5, 2]
[0, 0, 0, 1]
[3, 4, 6, 1]
[2, 3, 5, 3]
LXF Mine2o48 > up
[1, 4, 5, 2]
[3, 3, 6, 2]
[2, 1, 5, 3]
[0, 0, 0, 0]
LXF Mine2o48 > right
[1, 4, 5, 2]
[0, 4, 6, 2]
[2, 1, 5, 3]
[0, 0, 0, 1]
LXF Mine2o48 > up
[1, 5, 5, 3]
[2, 1, 6, 3]
[2, 0, 5, 1]
[0, 0, 0, 0]
LXF Mine2o48 > right
[0, 1, 6, 3]
[2, 1, 6, 3]
[0, 2, 5, 1]
[0, 0, 0, 2]
LXF Mine2o48 > down
[2, 0, 0, 0]
[0, 0, 0, 4]
[0, 2, 7, 1]
[2, 2, 5, 2]
LXF Mine2o48 > 
```

RULES OF THE GAME

A key tenet of programming anything is knowing what the rules are—knowing exactly how your program should behave in a given set of circumstances. A vague idea of what should happen often won't cut it: We need specifics and exactitude, free of any semblance of ambiguity. With that in mind, let's consider how the game of *2048* works.

We start with a 4x4 grid, which has some 2s and some 4s on it at random locations. Initially, two tiles are populated. The player can make one of four moves, shifting the tiles up, down, left, or right. Suppose the player chooses left, then the following algorithm applies: For every row, start by moving all the numbered tiles left, so that any empty tiles are on the right of the row. Now we look at each tile's situation, and decide how the tiles change. Starting with the tile on the left, if the tile to its right has the same value, then the left-most of the pair doubles in value, the right-most of the pair vanishes, and all tiles to the right move one position left. Repeat this process for the second and third tiles from the left. Repeat the whole process for the second, third, and fourth rows. If there is still space, then another 2 or 4 tile is added randomly in one of the available empty spaces. If no move is possible after this, it's Game Over.

For other directions, the same algorithm applies, with strategic substitution of row with column, and right with left, up, or down. Spotting the repetition here is important, too.

setting up the "mc" object, and using it to get the player's position. This provides a reference point for drawing our board, which we arbitrarily decide to be three blocks away in the z direction. Make sure you're not looking at the back of the board, though, because everything will be backward. For convenience, we also have a "printTiles()" function, which draws the board at the command terminal. We display only the exponents, because (a) we're lazy, and (b) it looks nicer if most things occupy just a single character. Change it if you like.

›› The "drawBoard" function uses different colors of wool (blockType 35) to represent the content of our array tiles [**Image C**]:

```
def drawBoard(self):
  for j in range(self.boardSize):
    for k in range(self.boardSize):
      self.mc.setBlock(self.x + k, self.y - j, self.z, 35, self.tiles[j][k])
```

›› This works reasonably well, but feel free to add to it [**Image D**]—making fancy glowing obsidian blocks for the higher valued ones, for example. Note that our "row[0]" is the top one, so we count down, subtracting j from our y co-ordinate.

6 THE ONLY WAY IS LEFT

But wait—there's an elephant in the room. We still haven't dealt with the three other moves allowed in *2048*. We could do this by copying the "leftMove()" function and painstakingly changing all the ranges and indices, and plus and minus signs, going through all the incorrect combinations until we find one that works. But that would be silly, and we don't tolerate such inefficiency here. Let's take a more grown-up approach. First, observe that moving the tiles to the right is exactly the same as reversing the rows, moving the tiles to the left, and then reversing the rows again. Reversing the rows is easy, once you figure out how to make a structural copy of our two-dimensional list:

```
def revTiles(self):
  oldTiles = [j[:] for j in self.tiles]
  for j in range(self.boardSize):
    for k in range(self.boardSize):
      self.tiles[j][k] = oldTiles[j][self.boardSize - k - 1]
```

›› Then we can make implement the (ahem) right move, just so:

```
def do_right(self,args):
  self.board.revTiles()
  move = self.board.leftMove()
  self.board.revTiles()
  if move:
    self.updateBoard()
  else:
    print "No move"
```

7 MOVING ON UP

But the symmetry does not stop there. We can construct the "Up" move by transposing our "tiles" array (replacing each row by its respective column), then performing our "leftMove()," and transposing back again. Transposition is almost exactly as easy as row reversal:

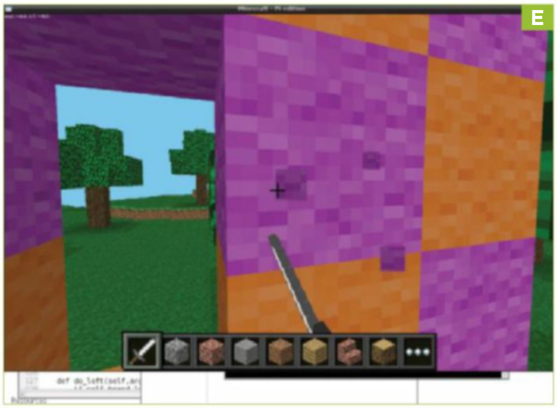
```
def transposeTiles(self):
  oldTiles = [j[:] for j in self.tiles]
  for j in range(self.boardSize):
    for k in range(self.boardSize):
      self.tiles[j][k] = oldTiles[k][j]
```

›› Similarly we can complete our directional command set, making the "Down" move by a combination of transposition, row reversal, left move, row reversal, and transposition:

```
def do_down(self,args):
  self.board.transposeTiles()
  self.board.revTiles()
  move = self.board.leftMove()
  self.board.revTiles()
  self.board.transposeTiles()
```

›› Note that this is the same as transposition, right move, and transposition.

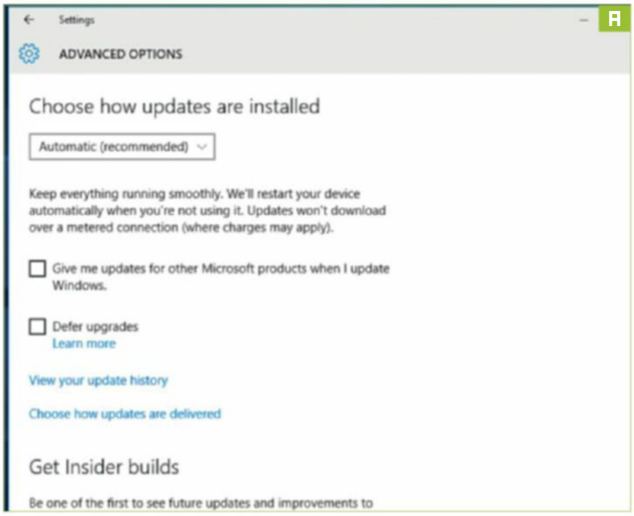
›› Spotting wee tricks like this is great because they not only make your program smaller (our provided code is about 160 lines long—not bad for a whole mini-game that can sap hours from your life) [**Image E**], but they also make it much easier to debug. The "leftMove()" function is by far the most complicated, so not having another three very similar functions is a considerable benefit. ⏻



E

Windows 10 Installation Problems Fixed!

Luis Villazon solves common installation problems



ADVANCED OPTIONS

Choose how updates are installed

Automatic (recommended)

Keep everything running smoothly. We'll restart your device automatically when you're not using it. Updates won't download over a metered connection (where charges may apply).

☐ Give me updates for other Microsoft products when I update Windows.

☐ Defer upgrades
Learn more

View your update history

Choose how updates are delivered

Get Insider builds

Be one of the first to see future updates and improvements to

Q **A FRESH START**
I've been using Windows 8.1 since it came out, and I've always suspected—but never been able to prove—that I had some viruses or other stuff installed. Nothing I've tried has got rid of it, including reinstalling. I'm wondering if installing Windows 10 might help. Will upgrading clear everything out, including viruses?

A You shouldn't assume it's a virus every time your PC runs slowly, crashes, or doesn't do what you want. If you think you have a virus, boot into Safe Mode and run a free online scanner, such as the one at http://housecall.trendmicro.com. If that comes up clean, you don't have a virus.

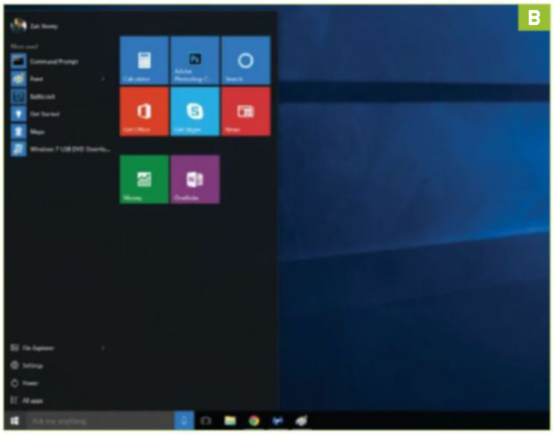
›› If you did have a virus under Win 8.1, upgrading to Win 10 won't get rid of it. The upgrade process leaves your documents and applications alone, and nearly all Win 8 executables also run under Win 10, so any infected files on your old system would be free to run the virus code on the new system as well.

Q **PLUNGED INTO DARKNESS**
I upgraded to Windows 10 from Win 7, and the screen went black after the first reboot. It came back during another reboot in the upgrade process, but then it went black again—and stayed that way. Stupidly, I didn't back up before I began the update, so I can't roll back. I've tried swapping the monitor and it makes no difference. I've tried hitting F8 to get Safe Mode, but that doesn't work either. What are my options?

A This is partly Microsoft's fault for not testing Windows 10 on the particular graphics card and driver combo you are using. But, it goes without saying, that it's really important to back up. If you had a valid backup, you could then roll back to Windows 7, enable Remote Desktop Protocol (RDP), run the Win 10 upgrade again, and then use RDP to connect to your blank-screen PC from another one, and fix your graphics driver problem. You can't boot into Safe Mode from Windows, because you can't see what you're doing, and most modern PCs with UEFI BIOSes and SSDs boot much too quickly to detect the F8 keypress. This means you'll have to temporarily install an alternative cheap graphics card just to give you some eyes on the ground. Then you can go to Nvidia or AMD, and download updated drivers that work with Windows 10.

Q **ARE UPDATES BAD?**
I upgraded to Windows 10 on release day and, so far, it runs like a dream. But I'm concerned about this automatic updates thing. People have been telling me it can't be turned off, and some of my friends aren't upgrading because they say this could be a security risk if one of the updates has a bug or something. If it is a risk, is there a way of disabling the updates?

A Automatic updates are compulsory in the Home edition of Windows 10 [**Image A**]. If you have Windows 10 Pro, you can defer your updates for a few months, to give your IT department time to test it with your existing drivers.



» While it is theoretically possible for a bug to get in, it's a much lower risk than that of leaving automatic updates off. Security updates are released to patch known vulnerabilities. By definition, every day that you don't patch this hole is a day that you are vulnerable. No Windows update has ever been released with malware in it, and the version of Windows with the least consistent update record (XP) is also the version most infected by malware. Forcing automatic updates will make Windows 10 the least infected version, and is the most important security advance since Microsoft started making updates available online at all.

Q

MORE LIKE THE "STOP MENU"!

Is there a way to add any program to the Start menu in Windows 10? When I drag a file on to it, nothing happens. I heard that creating a shortcut in C:\ProgramData\Microsoft\Windows\Start Menu\Programs would do it, but this just gives an error message.

A It sounds as though you're not logged in as administrator—C:\ProgramData is for the system Start menu [**Image B**], which is global for all user accounts, and you need to be administrator to write there. Even if you are administrator, some apps don't like launching from there. Try "%appdata%\Microsoft\Windows\Start Menu\Programs" instead. If you open a command prompt window, you can type "CD," followed by this path name, and hit Enter to navigate there. Or else you can use Windows Explorer to open C:\Users\your username\AppData\Roaming, which is what the "%appdata%" normally expands to.

» But, really, this is just tinkering around the edges. What you need to do is give yourself administrator access on your account. If it's your PC, you should normally be logged in as administrator if you ever want to get anything done.

» Non-admin accounts are for young children and guests. If the PC isn't yours, ask your parent/spouse/room-mate to give you a proper login. Or you could always get your own PC and lock them out of it, if you prefer to escalate things.

Q

WHEN IS SIX LESS THAN TWO?

I would like to take advantage of my free upgrade to Windows 10. I registered for the upgrade, but on the release day, I was told I don't have enough RAM on my PC. The trouble is, I do! I have 6GB currently installed, and Windows says it needs at least 2GB. What can I do? Would adding more RAM help?

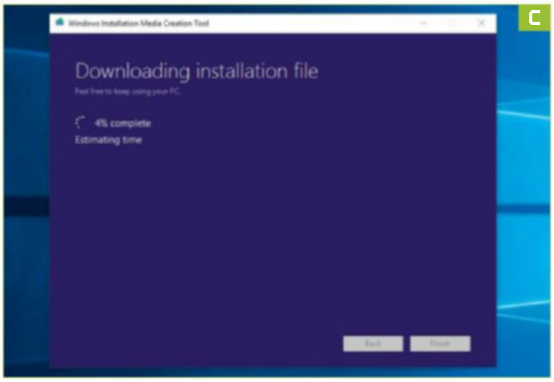
A We've seen this situation a couple of times. The Get Windows 10 app isn't perfect, and sometimes it misidentifies the amount of RAM that is installed on your PC. This might be because of an odd RAM configuration, or maybe you have some software running that is somehow masking how much the rest of Windows can see. It's also possible, of course, that one of your RAM modules is faulty, and you do, in fact, only have 2GB of physical RAM. But assuming you can reboot with just the 4GB module, this might shake things up enough to let you upgrade.

» Get Windows 10 isn't a first-come-first-served queue, though. It also takes into account compatibility. So, if your PC is old or unusual, and you also hobble it by leaving it with only just enough RAM, you might find that you don't get an invitation to upgrade for a few weeks more. If you can't be bothered to wait, just run the installer directly from www.microsoft.com/en-us/software-download/windows10ISO [**Image C**].

Q

WE ALL SCREAM FOR WIDESCREEN

I was wondering who chooses which resolutions make it to the standard list of screen sizes that Windows and monitors accept? Why is it 1280x1024, for instance, and not 1200x1000, or 1500x1100? And why is 1366x768 still common in Windows 10 laptops? It's not a multiple of anything in either direction, and 683:384 is hardly a standard aspect ratio!



Downloading installation file

Feel free to keep using your PC.

4% complete

Estimating time

A 1366x768 is actually 16.008:9, which is actually only off from the standard 16:9 widescreen resolution by less than 0.05 percent. In other words, it's the closest even-numbered horizontal resolution that converts a 1024x768 resolution into widescreen.

» Why 768 vertical pixels, you ask? In the beginning, there was CGA resolution, which was 320x200. This was horrible, and didn't fit properly on 4:3 aspect ratio TVs, so they doubled it horizontally, and slightly-more-than-doubled it vertically to produce VGA, which was less horrible. If you double that in both directions again, you'd get 1280x960, but this requires more than 1Mb of screen buffer. By the time graphics cards became good enough to do that, we were watching TV on widescreen. It's much easier to downscale 1080p HD to 1366x768, because they are both 16:9 aspect ratios. And if you need 4:3 resolution, you can stick some black bars on the side and call it 1024x768.

» In fact, the odd one out here is really 1280x1024—not 1366x768—because 1280x1024 is the only 5:4 aspect ratio screen resolution, which means it doesn't display well on just about any modern screen. The only reason it probably lasted so long is that 1,024 is a round number in binary, and is therefore easy for chip designers to address.

Q

MIND CONTROL

I'm new to Windows 10, and was wondering where Control Panel went.

A It's gone to the same place Control Panel always goes every time there is a new version of Windows: into the realms of confusion, hidden behind new and mysterious aliases and analogs. Control Panel has the least consistent interface design of any part of Windows, and that's still true in Windows 10. In fairness, Win 10 has slightly improved the situation over Win 8, but it has achieved this with a new layer that stands between us and the Control Panel we actually need.

» The new layer is Settings, which you can reach from the Start menu directly. It has a pared-down interface, with icons for the most common options, which are easy to tap on a touch screen. You can still open the old Control Panel by searching for it on the Start menu. But note that there's no direct correspondence between Settings and Control Panel—neither is a direct subset of the other. ⏻

Combine Two Color Images Together

YOU'LL NEED THIS

ADOBE PHOTOSHOP
Subscribe to various Adobe packages at www.adobe.com.

TWO APPROPRIATE PHOTOGRAPHS
Including one with interesting colors and textures.

WE'VE COVERED DOUBLE-EXPOSURE images before, but our previous example was a monochrome image, so this time we'll look at blending color photos together. Working with color files makes things a lot more complicated. You need to be even more discerning in your choice of source images, because not every picture blends well with others.

We're also going to show you a different way of selecting part of your image: drawing a path. This is a technique used a lot in the publishing industry, and if you've ever seen a cutout image in a magazine or newspaper that appears to be leaving its frame, it's likely it was done this way.

Rather than hunting through your Lightroom library, looking for images that will work, going out with your camera in search of them can inject a bit of fun back into your photography. Whatever you do, remember there's no wrong way to mess with your photos—you can always undo. **–IAN EVENDEN**

1 REMOVE THE BACKGROUND

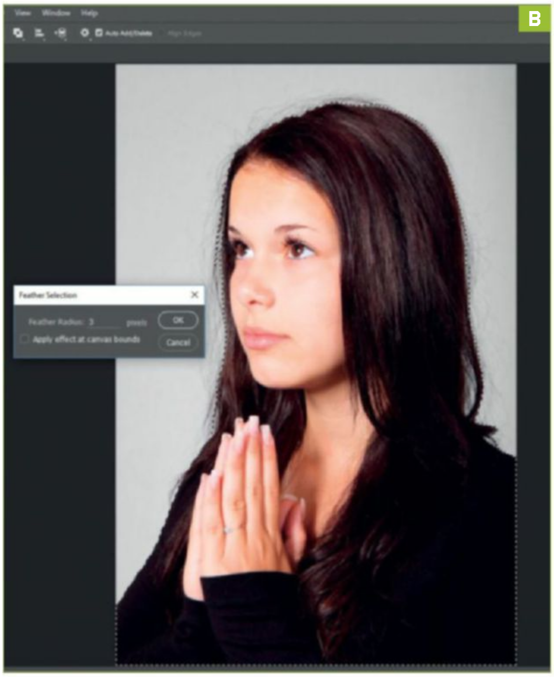
First of all, we need to separate our young lady from her background. The plain gray of the backdrop makes it a candidate for the Magic Wand tool, which selects contiguous areas of the same color, but there are some strands of hair falling away from her face that might interfere with the process. We also want to show you something new. So select the Pen tool, which looks like the nib of an old-fashioned fountain pen, and prepare to enter the strange world of vector paths. We're using Photoshop CC for this, but all the tools are available in Photoshop Elements from version 11 onward.

2 DRAW A PATH

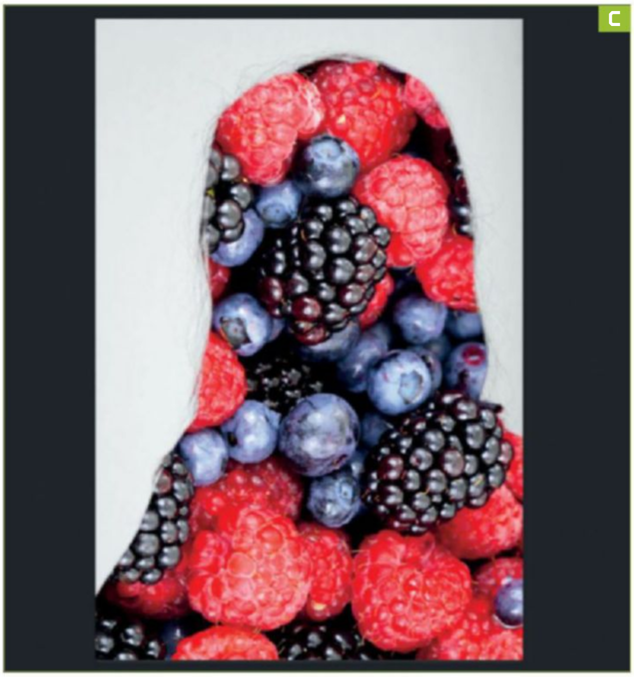
The Pen tool is the backbone of Adobe Illustrator, where it creates the lines and shapes that are the foundations of every illustration, but in Photoshop it serves a lesser purpose. It draws a "path"—essentially, a line that's defined purely by numbers, rather than pixels, and which is invisible until you "stroke" some color on to it, or otherwise manipulate it. We like to click the "rubber band" checkbox on the settings cog, which makes the path you're drawing more visible, but this is a matter of personal preference. Click once at the bottom of the image, where the young lady meets the backdrop, and a square appears. This is a "point." Click again a little further up, and a second one appears, and you can drag the mouse to make the path between the points fit exactly on the border. You need to make sure that your path only has to make one curve between points [**Image A**]. After the second point, your path may bend off in a direction you don't want it to; Alt-click on the point to get it under control.

3 USE THE FEATHER TOOL

This can be a fiddly way of selecting, but it's very accurate and not as frustrating as drawing freehand with the Marquee tool. When you get to the hair, stay a few pixels inside the border, and ignore any stray hairs. You'll get a very smooth edge as a result, but it will look more natural—and lead to less tooth-grinding—than if you try to envelope every single hair in your path. Once you've got to the bottom of the lady, opposite where you started, join the path up by clicking on the first point again. Then, on the Paths palette ("Window → Paths," if it's not already visible), double-click the "Work Path" to give it a name and save it, then, with it selected, click the dotted circle icon at the bottom of the palette—this loads it as a selection. We're going to feather the edge of the selection to make it softer, so head to "Select → Modify → Feather," and choose a Radius of 3 [**Image B**].



Feather Radius: 3 pixels
☐ Apply effect at canvas bounds

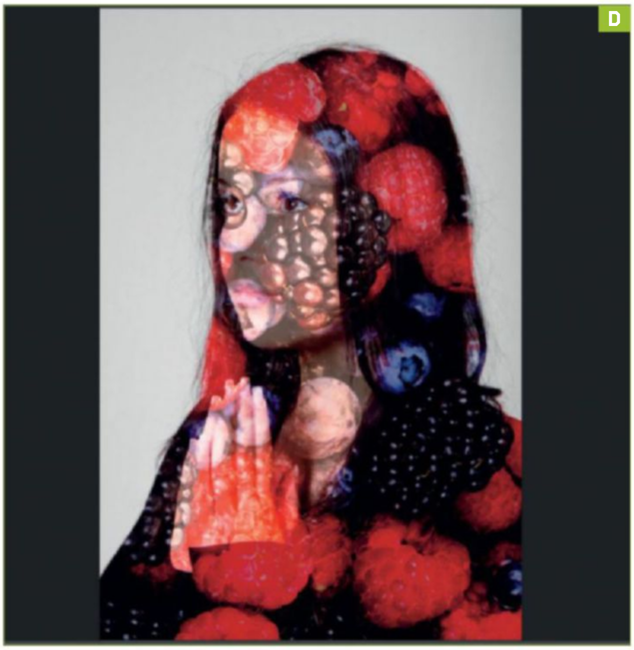

C

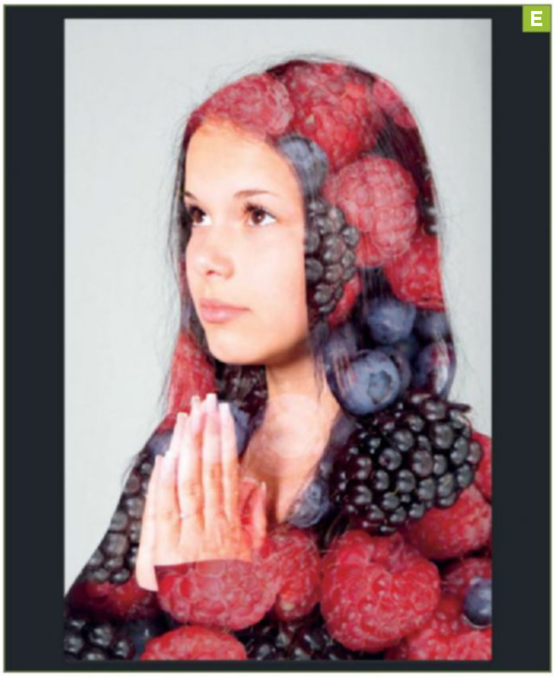
4 ADD YOUR SECOND IMAGE

Clear away the background by inverting the selection ("Select → Inverse") and Clearing it ("Edit → Clear"). Invert it back again, then save the selection ("Select → Save Selection") and deselect it. Open the second image you'll be using. We've chosen some fruit, the dark reds and blues of which should blend nicely with our model's dark hair and cardigan. Bring this second image in as a new layer, putting it at the top of the stack in the Layers palette. Move and scale it so you think it's in a good place, dropping the Opacity slider in the Layers palette to help you, if you need it.

5 USE BLEND AND OPACITY

Load your saved selection back ("Select → Load Selection"), and it should appear on top of the fruit. Hit the "Layer Mask" button we showed you last month—at the bottom of the Layers palette, looking like a rectangle with a circular hole in it—and you should get a young-lady-shaped picture of fruit [**Image C**]. Changing the Blend Mode of the top layer to "Multiply" allows the lower to show through, darkening the colors where they overlap. Experiment with which Blend Mode and Opacity level looks best—in our example, "Screen" brought out the model's face, while "Hard Light" really allowed the colors of the fruit to show through, but needed us to ease back on the opacity to avoid looking like something from a yogurt advert [**Image D**].


D


E

6 FINISHING TOUCHES

If you want to remove areas from the blend, click the black and white portrait of the Mask itself in the Layer's palette, and paint white on to it with the Brush tool. This subtracts areas from the Layer Mask, while painting black would have the opposite effect. We've gone over the girl's face in white, removing all traces of fruit from it [**Image E**]. When you're happy with your final image, save it as a PSD file to preserve the layers, then go to "Layer → Flatten" to merge all the layers into one, and "File → Save As" to create a JPEG. ⏻

REFINE EDGE

The Refine Edge tool ("Select → Refine Edge") helps smooth the edge of your selection once you've made it. Check "Smart Radius," and extend the Edge Detection slider to pick up any escaped hairs you didn't select the first time. You can click the brush icon and paint over any areas you want to get inside the boundary of the selection, and the Smooth slider below evens out any parts of your selection that might have gone a bit jagged. Pressing F cycles through a few view modes, so choose the one that enables you to see what's going on most clearly, then hit "OK" when you're happy. You can output the selection direct to a Layer Mask using the drop-down menu.

BUILD IT

ZAK STOREY, STAFF WRITER

The Goliath Workhorse

Intel and Nvidia join forces to power one gnarly rendering machine

LENGTH OF TIME: **2-3 HOURS**

LEVEL OF DIFFICULTY: **EASY**

GEFORCE GTX

THE CONCEPT

WHETHER IT'S 900bhp hypercars or the full, unbridled fury of an Atlas V rocket heading into low-earth orbit, there's something about insane power that inescapably draws all human beings toward it. Breaking barriers is in our nature. It's what our species does best. Although it's rarely cost-effective or realistic, having access to the ludicrous is something the vast majority of us covets.

Without a doubt, then, we can safely say this machine has a hint of craziness about it. Let's be honest, you know why we pieced this machine together: To show off the incredible madness held within the depths of each of those wily sub-16nm high-end processors.

So how do we justify a machine like this? As a 4K gaming workstation. That's our excuse for putting this monstrosity together. There's no fancy custom loop water cooling found here, no complicated setups, or anything along those lines. Just simple plug and play hardware, and a hell of a hit to the old wallet. But if you need it, you need it.

A RENDERING GIANT

HOW DO YOU piece together a leviathan like this? Well, the CPU is always a good place to start. The Core i7-6950X (review pg. 72) is Intel's first deca-core processor, and coming in at a respectable (ha, who are we kidding—it's insane!) $1,569, it's the backbone of our PC. We coupled that with Asus's updated X99-A II motherboard (review pg. 80.) Although not as high-end as its deluxe series, it still has all the features and expandability options we were after.

We had to couple that with 64GB of Corsair's finest, a fully digital 1,000W power supply in the form of the HX1000i, and a case: a Corsair Carbide 400C. This mid-tower chassis has ample room for dependable airflow, and its clean, straight lines ensure we'll be getting a build that looks as classy as its price tag. We did consider the 600C, but that inverse layout has caused enough controversy since its release. For storage, we opted for 12TB of Western Digital's Black drives, and a single 1.2TB PCIe NVMe Intel 750 SSD for the OS.

But wait! We can't forget about that pixel-rendering beauty sitting in the middle of this beauty: the GTX 1080 (review pg. 74). The world's most powerful single GPU right now. Although a bit of a price hike in contrast to the GTX 980—even if we were using the non-Founders Edition—it's still the biggest and best graphical kid on the block. Our only regret? We wished we had two for this build.

INGREDIENTS

PART		STREET PRICE
Case	Corsair Carbide 400C	$80
Motherboard	Asus X99-AII	$250
CPU	Intel Core i7-6950X @ 4.3GHz	$1,569
Memory	Corsair Dominator Platinum 64GB (8x 8GB) 2,400MT/s	$470
GPU	Nvidia GeForce GTX 1080 Founders Edition	$699
PSU	Corsair HX1000i	$185
Storage 1	Intel 750 Series 1.2TB PCIe NVMe SSD	$1,018
Storage 2	2x WD Black 6TB 7,200rpm HDD	$550
Cooling	Corsair Hydro H100i v2, 2x Noctua NF-F12 iPPC 120mm, 2x Noctua AF-F14 iPPC 140mm	$198
Total		$5,019

1

CASE WOES

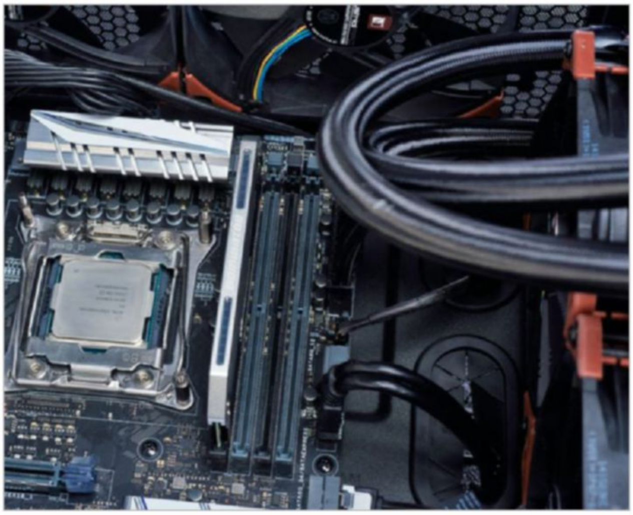
THE 400C is one of the cleanest cases out there, but there's a few things you should bear in mind. Firstly, the power supply cover. To install your PSU, you need to remove that little devil by undoing the three screws on the rear of the motherboard tray. You can then remove the panels and gain access to install the PSU. Unfortunately, there's no other way to install it. Next thing you'll want to do is slide the 3.5-inch hard drive bay across to the left—there are another two thumbscrews located just below the ones from the PSU cover for this. By doing this, you gain extra space to plug in your cables and keep everything nice and organized. One quick tip: Install the PSU and route the CPU power up to the top of the chassis prior to installing the motherboard. It'll save you a lot of effort in the long run.

CORSAIR
HX1000i
/ISUS

2

MEMORY AND COOLER

FOR THIS BUILD, we chose Corsair's Hydro H100i V2. We'll be honest, there's not a lot of difference—certainly from an installation standpoint—between different AIO coolers. In this chassis, we chose to install the radiator in the front of the case, ensuring we could pull cool air into the system. Install your radiator and fans before your motherboard; this way, you can route the fan cables where they need to be ahead of time, so there's no hassle later on, trying to install them around your hardware. It's also a smart move to install your memory first, before attaching the heatsink, so you avoid trying to maneuver your DIMMs around the AIO's tubing runs. DDR4's notches are a little more subtle than DDR3, so make sure you line up the notch on the bottom of the DIMM with the notch on the motherboard.



3

PCIE STORAGE

INTEL'S 750 SERIES PCIe SSDs bring large capacities and jaw-dropping read and write speeds to the masses. We took advantage of the 1.2TB variant, coming in at $1,018. If that's a little beyond your budget, you could easily opt for a smaller 400GB version instead, to house your OS and most-used programs. On top of that, if the PCIe card look isn't your jam, or if you fancy running GTX 1080s in SLI, Intel also sells a 2.5-inch variant that connects to the Asus X99-A II via the U.2 standard. And if you really can't be fussed with that, you could opt for a Samsung 950 Pro instead—although it can throttle just a touch under load, this M.2 drive will sit snugly below your graphics card, making placement infinitely easier.

4

INSTALLING 3.5-INCH DRIVES

INSTALLING THE two mighty 6TB WD Blacks can be a little tricky, especially as the Corsair 400C is a fairly compact case. Make sure you run your SATA cables from your motherboard first, and ensure you've got a SATA power daisy chain running out of your PSU. Another pro tip is to avoid any of the angled SATA cables—your best bet is to use straight ones, especially if you're occupying both bays. These two Western Digital Black drives boast some insane capacities, ensuring you'll have plenty of redundancy for when the crap hits the fan. We chose to keep them stock, but setting up a RAID 1 or 10 array isn't a bad idea. On top of that, there are three additional 2.5-inch slots on the back of the motherboard tray, if you want to expand your SSD storage even further.

5

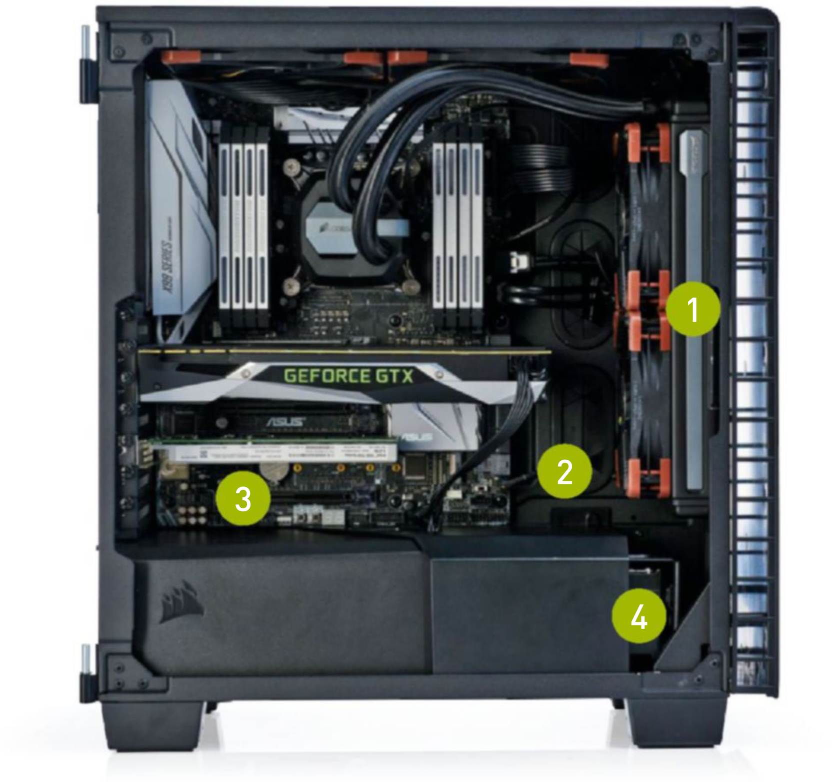
KING OF THE HILL

THE GTX 1080 is the pinnacle of single GPU graphics technology at the moment—it kicks absolute ass—but, in relative terms, not a lot has changed since the last generation, as far as installation goes. Plug it in, screw it down, make sure it's got enough breathing room, remember it's a blower-style card—it sucks air in for its coolant, as opposed to circulating it—plug in your power, and you're good to go. The biggest change for us lies in that single 8-pin power connector. Although you could, hypothetically, daisy-chain two GTX 1080s off a single cable, we advise against it, especially considering how power-hungry these babies are. Your best bet is to run two separate cables up to each of your GPUs here, especially if you want to overclock them. And, boy, do these things OC!

6

FILLING THE LOOP

WE'RE A BIG FAN (ha!) of Noctua here in the office—who isn't?—and, for this build, we opted to pump the air around with these little beauties. We chose to run two Noctua NF-F12 iPPC 2,000rpm 120mm fans for the front AIO cooler, pulling cool air through the radiator and into the chassis. And then we have two NF-A14 iPPC 2,000rpm 140mm fans drawing cold air directly in through the roof. There's a couple of reasons for this. Firstly, the horrendous number of cables littered across the top of the motherboard is a nightmare—having them potentially get caught in the fan blades is just going to suck. Secondly, a positive pressure system will make cleaning out your system a little easier in the long run, because all the air drawn into the chassis is filtered, and it's pushed out of all the unfiltered areas. We're all about that system maintenance.



1 If you really want to get the maximum cooling potential out of this little chassis, you can opt to install a 280mm AIO instead of the 240mm we used. However, it still needs to go in the front, because roof spacing is still just too tight.

2 In hindsight, to make this build tidier, we should have opted to run the single 8-pin PCIe power through the grommet to the right of the motherboard/GPU. Although it's absolutely fine coming out of the floor like that, it does look a little awkward and out of place.

3 The 400C in combo with this motherboard has plenty of space for an SLI setup. In fact, if you dropped the Intel 750 Series SSD down one slot, and installed a GTX 1080 in its place, you would have zero airflow problems, and one cool SLI powerhouse.

4 The only downside with the PSU cover in the 400C is that you can't extend it all the way across. We understand it's there to ensure sufficient radiator support for 360mm AIOs and radiators, but the option would have been nice to hide our HDDs completely, once slid across.

THERE ARE RENDERING STATIONS, THEN THERE'S THIS

HINDSIGHT IS A WONDERFUL THING. When it comes to building your own rig, it's a vital tool for helping you improve your technique and knowledge for next time. Forethought and planning—that's what's key. For this Build It project, it was all about cable management and studying how the chassis worked.

Take the X99-A II motherboard, for instance. It's a swell update on Asus's last iteration, but there's one problem: the position of the CPU power. As it's direct center, at the top, it makes it difficult to route your EPS 8-pin, especially in combination with the Corsair 400C, as it lacks a third rubber grommet in that central area. So, you end up trailing CPU power from the top-left of the chassis, right across the bottom of your fans. This also manages to cut off access to the three CPU PWM fan headers in the process. It's an immensely tight squeeze to get that EPS power connected when you have two additional 140mm fans, as well.

Even for us, these are problems we couldn't predict. Adapting and overcoming those predicaments—in our eyes, at least—is what makes being a PC enthusiast and building your own system so gratifying.

So, what do 10 cores, 20 threads, 64GB of DDR4, a 16nm FinFET GTX 1080, and over 13TB of storage gain you? One gnarly machine. Overclocking the Core i7-6950X was a doddle. We dropped in the 2,400MT/s XMP settings, switched off SpeedStep, enabled full power phase control, and started upping the multiplier and voltage until we reached a stable point for thermals and system stability. We managed 4.3GHz with a cushy 1.285V on the CPU core. And this is where that deca-core monster shone, racking up an astonishing 2,208 points in Cinebench R15. To put that into perspective, a mainstream Core i7-6700K @ 4.9GHz only manages 1,074, and the last-gen i7-5960X eight-core processor can only hit 1,387 points at stock. Mind blowing. Other than that, we saw an impressive 8,400 points in PC Mark 8's Creative benchmark, and 3D Mark's Fire Strike scored well over 18,000 points—that's a thousand points higher than just utilizing an i7-6700K with the GTX 1080, which goes to show how much those additional cores benefit advanced physics simulation.

This machine is overkill, no doubt about it. It's $5,000-plus of grade A red meat rammed into a sleek, clean chassis. The perfect 4K render workstation, that also excels at gaming. There's only a few things we'd change: a custom cable kit to make this build look incredibly clean, and perhaps another GTX 1080 Founders Edition, with one of those swanky new SLI bridges Nvidia has developed. That would have capped it off as one of the best consumer workstations in the world.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	1,074	2,208 (106%)
Cinebench R15 Single Thread	213	176 (-17%)
TechARP's x264 HD 5.0.1 (fps)	24.6	45.6 (85%)
PC Mark 8 Creative	7,675	8,400 (9%)
Rise of the Tomb Raider	41	65 (59%)
Far Cry Primal	76	102 (34%)
The Division	78	105 (35%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM.
All games are tested at 1080p on max settings, with HD texture packages installed.

LOST CIVILISATIONS, MYSTERIOUS PHENOMENA, AND MUCH MORE…

DISCOVER SCIENCE SERIES
148 PACKED PAGES
Biggest Mysteries in Science
ORDER NOW!
INSIDE
• How old is the Sphinx really?
• Is there a Bigfoot out there?
• Do UFOs visit our planet?
FACTS VS FICTION
DREAMS EXPLAINED
STONE AGE SECRETS
BIBLE CODES EXPLORED
UFOS INVESTIGATED
BIGGEST MYSTERIES IN SCIENCE

DELIVERED DIRECT TO YOUR DOOR

Order online at **www.myfavouritemagazines.com**
or find us in your nearest supermarket, newsagent or bookstore!

REVIEWS

TESTED. REVIEWED. VERDICTIZED.

INSIDE

72 Intel Core i7-6950X

74 Nvidia GeForce GTX 1080

76 Razer Blade

79 Razer Ripsaw

80 Asus X99-A II

82 Philips BDM4350UC

84 Oculus Rift

85 HTC Vive

86 Corsair K70 RGB RapidFire

87 Corsair M65 Pro RGB FPS Gaming

88 Doom

90 Total War: Warhammer

92 Lab Notes

RAZER BLADE
PAGE 76

Intel Core i7-6950X

The world's first consumer deca-core processor. Now, who's paying?

INTEL CONFIDENTIAL
NA
QKVN 3.00GHZ
L552C735
M6KM916501102

Ten cores and twenty threads. What's a guy to do with 'em?

THIS IS THE BIGGY. The very latest word in ultra-enthusiast desktop processing—the 10-core Intel Core i7-6950X. And what a beastly slice of silicon it is. While Intel's processing cadence is stuttering at the standard consumer end, its "tick-tock" release schedule is still on track in the high-end desktop (HEDT) arena. So long as you forgive the fact it's taken two years to move from Haswell-E to Broadwell-E.

That aside, the 6950X is the pinnacle of the high-end tick, taking the existing Haswell core architecture, and shrinking down the smallest transistors to a freakishly tiny 14nm lithography. Because it's just an Intel tick, though, little else has fundamentally changed between this and the previous HEDT chip, the Core i7-5960X.

There's the same 140W TDP, the same 40 PCIe 3.0 lanes, and the same 3GHz/3.5GHz base/Turbo clock speeds. You do get a slight revision in the Turbo Boost technology, and the base DDR4 memory support has been upped from 2,133MHz to 2,400MHz, but that's pretty much it. OK, we'll stop ignoring that wrinkly gray thing in the room—there's also another two cores.

Now, before you get too excited—and, we'll acquiesce, a deca-core consumer processor is definitely exciting—Intel isn't just throwing those extra two cores into the new generation of processors for free, as it did with the shift from the six cores of Ivy Bridge-E's i7-4960X to the eight of Haswell-E's i7-5960X. That's because this isn't a direct successor to the previous generation's top processor; this chip sits outside of even those upper echelons of unaffordable silicon. This is the Titan X of CPUs. A chip designed not to really interact with the rest of Intel's range; a chip for those with very specialist multi-threaded needs, or the pay checks and must-have mentalities of top-end ball-players. And, as such, it comes with a frankly offensive $1,569 price tag. So, yeah, those extra two cores are going to cost you another $569 over the previous generation's best.

The actual successor to the Core i7-5960X (Haswell-E) is the tantalizing Core i7-6900K, an eight-core, $999 CPU with the same spec as the top Haswell-E chip, but with a 3.2GHz base clock and a 3.7GHz Turbo clock. We're holding out hope that's the king overclocker of the range. There's also a ginger stepchild of a six-core CPU in the circa-$600 i7-6850K, and another six-core, which is genuinely exciting. The i7-6800K is a $400 chip that could form the base of some stunningly affordable HEDT PCs, which will either cannibalize Skylake's 6700K or force some price reductions.

PERFORMANCE ART

But let's forget the outrageous cost for a second and consider performance—in that, the 6950X is unsurpassed. In multi-threaded tasks, it slices through all that's put in front of it with ease. With Cinebench R15 and the x264 encoding test, the Broadwell-E chip is well out in front of the best that Haswell-E could offer. It's not just by virtue of those extra cores either, which bodes well for both the 6900K and 6800K—the single-core performance of the 6950X has improved, too. There's still a SpeedStep issue with the Asus board we used for testing, which afflicted the Haswell-E chips, too, but with that turned off, you get the same improved single-core performance the Core i7-5775C (desktop Broadwell) exhibited.

That boosts the gaming performance, too, despite the Broadwell-E chip not Turbo-ing as high as its older sibling. The 6950X sticks around 3.4GHz for the most part, while the 5960X at stock speeds will consistently Turbo at 3.5GHz. In our initial testing, it missed the overclocking mark by 100MHz, with the latest chip topping out at 4.3GHz, while our 5960X happily hit 4.4GHz. That said, the 6950X did deliver an astounding score of 2,220 in Cinebench.

As expected, then, the 6950X is the very best in consumer processing, and will eat multi-threaded tasks for breakfast, followed by single-threaded ones for a Shire-ish second breakfast. But it's not the Broadwell-E chip we're going to be recommending. It's prohibitively priced, sits aside from the real meat of the Broadwell-E range, and almost only serves to demonstrate the engineering might of Intel's 14nm process by delivering the desktop its first deca-core CPU. And while it has pushed the six-core chips into a more affordable price point, it hasn't managed to do the same for the static eight-core.

It's a halo product—a technological wonder, rather than anything we would honestly recommend. **–DAVE JAMES**

BENCHMARKS

	Core i7-6950X	Core i7-5960X
Cinebench R15 Multi-Thread	**1,785**	1,387
Cinebench R15 Single Thread	**151**	142
x264 v5.0.1	**34.83fps**	27.36fps
SiSoft Sandra	**44.29GB/s**	43.39GB/s
PCMark8 (Creative, Accelerated)	**7,148**	6,985
5GB Compression Test	**218s**	235s
5GB Extraction Test	**101s**	119s
3DMark Fire Strike	**15,323**	14,781
3DMark API Test DX12	16.37 million	**16.86 million**
Total War: Attila	**54.8 (44)**	51 (39)
Rise of the Tomb Raider DX11	97.42	**97.66**
Rise of the Tomb Raider DX12	**105.27**	103.4
Temperatures: Idle/Load	**30 C/61 C**	33 C/63 C

Best scores are in bold. Test rig: Asus X99 Deluxe (no SpeedStep), Corsair H100i, Nvidia GeForce GTX Titan X, 16GB DDR4 @ 2,133MHz, 512GB Samsung 850 Pro, BeQuiet 1,000W PSU.

VERDICT
8

Intel Core i7-6950X

+ WONDERFUL Ten bleedin' cores; stunning multi-threaded performance; improved single-core prowess.

− WANDERER Offensively expensive; weaker Turbo speeds.

$1,569, www.intel.com

SPECIFICATIONS

Base/Turbo Clock	3GHz/3.5GHz
Cores/Threads	10/20
Lithography	14nm
Cache	25MB (L3)
Memory Support	64GB DDR4-2400
Memory Channels	4
Max PCIe Lanes	40
Graphics	N/A
Graphics Clock	N/A
TDP	140W

GTX 1080
NVIDIA

The new ruler of gaming graphics costs a king's ransom, rather appropriately.

Nvidia GeForce GTX 1080

All hail Pascal, the new king!

LADIES AND GENTS, Pascal has landed. The 16nm FinFET hero has finally arrived. It's the first in a new lineup of graphics processors that transcend the charms of the ultimately limited 28nm manufacturing process. And, today, we can confirm exactly what this little beauty holds within, and what the GTX 1080 means for Nvidia's next generation of bunker-busting GPUs. Even Kanye West is jealous of these babies.

So, what are we talking? 2,560 CUDA cores, 160 texture units, 64 ROPs, 9 TFLOPS of performance, a stock boost clock running at 1,733MHz, and 8GB of GDDR5X VRAM running at a solid 10,000MHz on a 256-bit memory bus. Glamorous, eh? What does that mean for the uninitiated? Think of it this way: A Titan X is capable of producing 7 TFLOPS, a GTX 980 Ti 6.5 and the now-lowly 980 can just about pump out 5.3. So spec for spec, the new GTX 1080 should slay its predecessor twice over.

Criticisms? Firstly, the GTX 1080 doesn't harbor the big Pascal GP100 core architecture found in Nvidia's high-end Tesla P100 graphics cards, announced earlier this year. No, this is GP104, akin to a scaled-down variant of Maxwell. But that's by no means a bad thing—Maxwell has incredible overclocking potential. On top of that, we've yet to see any hint of HBM 2.0; although we're expecting to see mainstream production roll out this year, it's likely we won't see a new generation of Titan or Ti field this bandwidth-munching monster until nearer winter.

That's not to say the 1080 lacks memory power. In fact, this is the first GPU to feature Micron's GDDR5X standard. Packing higher frequencies, higher capacity per chip, and better power efficiency, the 1080 has 8GB of 10,000MHz on a 256-bit memory bus, enabling a max bandwidth of 320GB/s. But enough specs, how does she perform?

As far as the thermals and power draw go, this is interesting. Overall, the GTX 1080 has a higher TDP than the 980, coming in at 180W, as opposed to 165W. However, temperatures are still quite low, with the card ramping up to 82°C with GPU boost. Of course, you can increase that limit to 91°C, similar to last-gen. What is notable is the cooling system. The single blower fan on the 1080 spins at a far lower rpm than the 980, so temperatures tend to ramp up higher before the fan kicks in, no doubt to save our ears from unnecessary noise.

1080P? HA!

In game, the GTX 1080 stomps on every GPU to date. Short of SLI/CrossFire configurations, and multi-GPU cards such as AMD's Radeon Pro Duo, there isn't much in the way of competition. It makes 4K gaming accessible. By no means is it a flawless 60fps experience in AAA titles, but we're almost there. Drop the unnecessary AA from our benchmarks at 4K (thanks, pixel density), and you can easily hit a 60fps average. That said, in *Far Cry Primal, The Division*, and *Ashes of The Singularity*, average frame rates were into the forties, with minimum frames not dropping below 20. At 1080p, it wasn't uncommon to see minimum rates in the 80s.

Our biggest gripe is with the price. For this particular card, the Founder's Edition, you have to fork out an additional $100. For the extra moolah, you net yourself a pretty box, the signature metallic shroud, and access to the 16nm GPU two weeks earlier than the AIB cards. The core is incredible, performance exceptional, but the pricing scheme just ludicrous. **–ZAK STOREY**

VERDICT
9

Nvidia GeForce GTX 1080

+ **GRATIFYING** Exceptional 4K performance; most powerful single GPU; single 8-pin power; fantastic overclock potential.

− **GRATUITOUS** Price hike for early adopters.

$699, www.nvidia.com

SPECIFICATIONS

GPU	Pascal
Lithography	16nm FinFET
Transistor Count	7.2 billion
CUDA Cores	2,560
Texture Units	160
ROPs	64
Core/Boost Clock	1,607MHz/1,733MHz
Memory Capacity	8GB GDDR5X
Memory Speed	10GB/s
Memory Bus	256-bit
TDP	180W
Display Connectors	DisplayPort 1.4, HDMI 2.0(b)

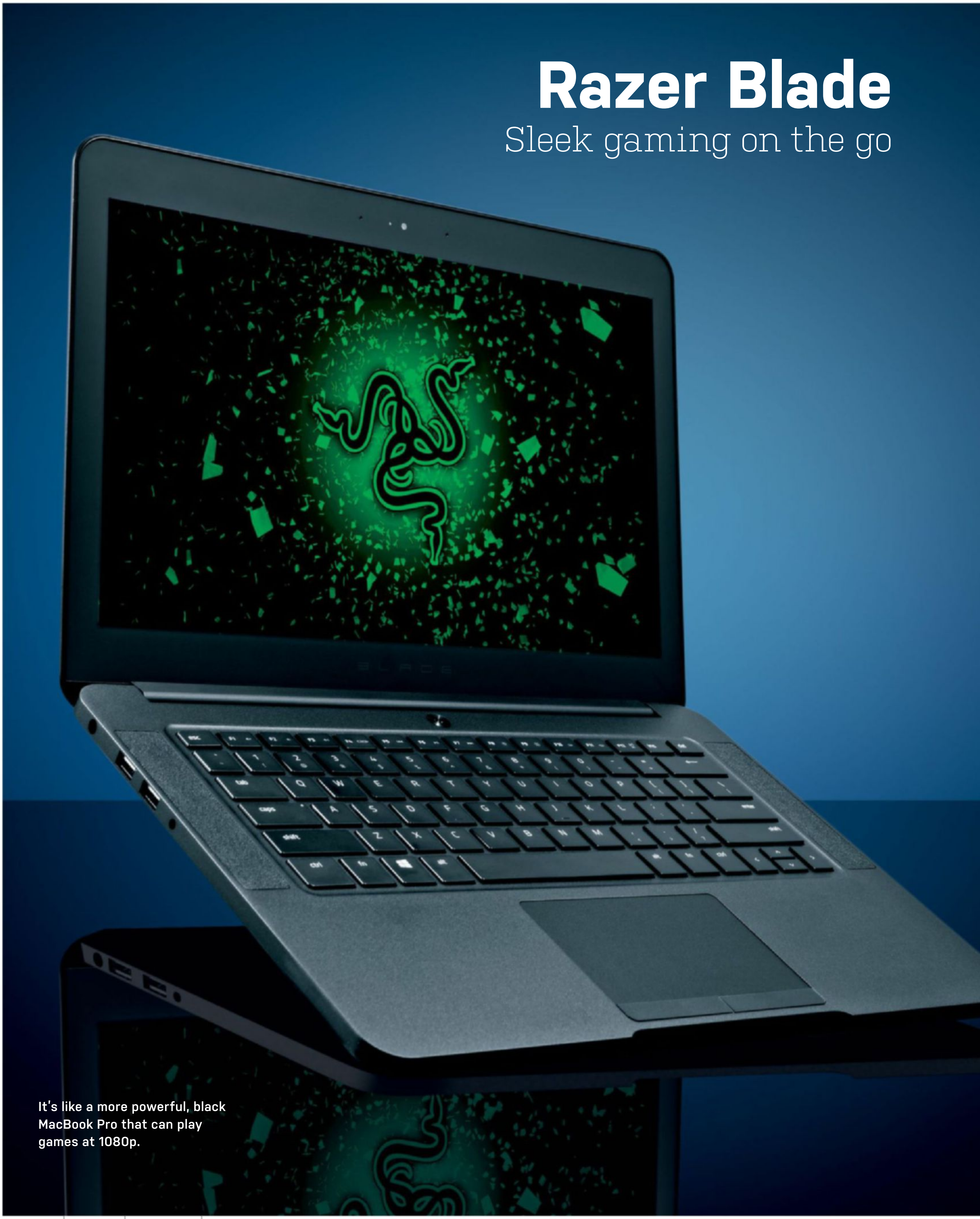
BENCHMARKS

	Nvidia GeForce GTX 1080	**Nvidia GeForce GTX 980**	**Gigabyte WF3 GTX 970**
Fire Strike @ 1080p	**17,016**	11,338	10,313
Fire Strike Extreme @ 1440p	**9,371**	5,822	5,366
Fire Strike Ultra @ 4K	**4,934**	3,132	2,803
Total War: Attila	**40/19**	23/11	20/10
Far Cry Primal	**77/42**	45/23	41/21
The Division	**84/46**	53/29	53/22
Rise of The Tomb Raider	**42/20**	20/4	17/2
Ashes of The Singularity	**49/39**	30/24	27/21
Power Draw Load	252W	**237W**	251W

Best scores are in bold. Game results are average fps at 1440p/4K. Our test bed consists of a Core i7-6700K, 16GB of Kingston Savage DDR4 @ 2400 MT/s, and an MSI Z170A Gaming M7.

Razer Blade

Sleek gaming on the go



It's like a more powerful, black MacBook Pro that can play games at 1080p.

MOBILE COMPUTING is full of form factors: convertible tablets, Chromebooks (and a few netbooks), ultrabooks, lightweight notebooks, such as the MacBook and ThinkPad, full-featured notebooks, and weighty gaming laptops. The Razer Blade takes some of the gaming chops of a full-featured notebook or gaming laptop, and stuffs them into a form closer to that of a MacBook Pro. And damn, Razer did it well.

The 14-inch Blade has a smooth, black, powder-coated aluminum finish. No plasticky feel here. The lid features a green illuminated Razer triple-serpent logo.

The comparison to a MacBook Pro isn't far off. The Blade comes with Intel's Skylake Core i7-6700HQ, like many gaming notebooks. The 6700HQ's base clock comes in at a respectable 2.6GHz, with a turbo clock of 3.5GHz. In contrast, the current-generation 15-inch MacBook Pro, at the same price as the Blade, sports a previous-generation i7-4770HQ Haswell CPU, with a base clock of 2.2GHz and turbo of 3.4GHz.

The Blade also comes with a hefty 16GB of RAM, and either a 256GB or 512GB Samsung PM951 SSD; we're reviewing the 250GB model here. The SSD capacities are the only real options you can choose from.

The pixel-pushing power comes from a GeForce GTX 970M with 6GB of VRAM. That's an improvement over the previous Blade, which only had 3GB, like most gaming laptops with the 970M. In our benchmarks, the 6GB served the Blade well, giving us solidly playable frame rates in *Far Cry Primal, Rise of the Tomb Raider,* and *The Division* at 1080p at Ultra settings (*Rise of the Tomb Raider* is run with SMAA and Very High settings). You won't hit 60fps at Ultra, but by tuning some effects back to High or Medium, it's well within reach. You're not going to see playable frame rates in these games at the Blade's native resolution of 3200x1800, unless you scale the quality settings way back, but 1920x1080 on a 14-inch screen is more than high enough to make games look sharp.

While running games and benchmarks, it's worth noting that the Blade got pretty damn hot. But what impressed us was where it got hot. Heat is concentrated near the hinge—the rest of the laptop stayed impressively cool, even under high loads.

The keyboard offers Razer's Chroma RGB LED illumination, which can be controlled from Razer's Synapse software. If you've ever used a Razer Chroma keyboard, all of the same options are there in Synapse. The keys are scissor membrane switches, but felt responsive. The trackpad is responsive, too, and has separate mechanical left and right mouse buttons—a thoughtful touch. The font on the faces of the keys has changed as well.

We left the Chroma illumination on for our battery test, and still managed 6 hours and 38 minutes while playing a 1080p movie on loop with Windows' Power Saver mode enabled. We kept the screen at 50 percent brightness, which equaled about 150 nits, instead of the 200 we usually test at.

In terms of connectivity, the Blade offers a respectable array of options. There are three USB 3.0 ports, with two flanking the left side and one on the right. The right side also features a Thunderbolt 3 connector, as well as an HDMI connector, and Kensington lock. The left side has an audio jack, too. For networking, the Blade comes with Killer's Wireless-AC 1535 802.11 a/g/b/n/ac, which offers Bluetooth 4.1 for wireless pairing. Bonus points here, because Killer offers support for Debian and Ubuntu Linux via the ath10k kernel driver. (You need the firmware from Killer's website, though.)

There's no RJ45 connector, but that's because it's so damn thin. An RJ45 jack can range from 11.5mm to 13.5mm in height. At 17.8mm (0.7 inches) thick (including the lid), the Blade is just a hair thinner than the MacBook Pro's 0.71 inches. The Blade is also thinner than the Asus ROG G752VT-DH72 (0.8 inches thick). There is a trade-off, though, as the thicker laptops have enjoyed better benchmark scores, likely due to the extra room for heat dissipation.

If you're a gamer on the go who doesn't want to carry around an eight-pound laptop requiring a backpack, we recommend you look at the Blade. If you're a creative who likes the MacBook Pro's build quality, but prefers Windows or Linux, this laptop offers the same premium feel and more power for the same price. **–ALEX CAMPBELL**

BENCHMARKS

	ZERO-POINT	
Cinebench 15	682	663 (-2.8%)
Cinebench 15 (Single CPU)	148	130 (-12.2%)
x264 HD 5.0 (fps)	15.17	15.02 (-1.0%)
PCMark 8 Creative	6,180	4,526 (-26.8%)
CrystalDiskMark QD32 Sequential Read	992.3	1,588 (60%)
CrystalDiskMark QD32 Sequential Write	163.1	307.6 (88.6%)
CrystalDiskMark 4K Read	44.2	43.6 (-1.4%)
CrystalDiskMark 4K Write	162.1	174.6 (7.7%)
Far Cry Primal (fps)	37.2	35 (-5.9%)
The Division (fps)	33.3	32.8 (-1.5%)
Rise of the Tomb Raider (fps)	58.5	40 (-31.6%)
3DMark Fire Strike	6,583	6,474 (-1.7%)
Battery Life: 1080p Video (mins)	153	398 (160%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero point is the Asus G752VT-DH72, with an Intel Core i7-6700HQ, a 3GB GTX 970M, and 16GB of DDR4-2133. *Far Cry Primal* and *The Division* tested at Ultra settings at 1080p; *Rise of the Tomb Raider* tested at Very High settings with SMAA at 1080p.

VERDICT
9

Razer Blade

➕ **DAYWALKER** MacBook Pro-like smooth aluminum build; 6GB VRAM; most of the body stays cool under load; long battery life.

➖ **DEACON FROST** Heat concentrated near hinge; no wired Ethernet.

$2,000, www.razerzone.com

SPECIFICATIONS

CPU	Intel Core i7-6700HQ
RAM	16GB DDR4-2133
Graphics	GeForce GTX 970M 6GB
Screen	14-inch 3200x1800 IGZO QHD+ touchscreen
Body Material	Machined aluminum
Storage	256GB Samsung PM951 M.2 NVMe
Battery	70Wh lithium-ion polymer
Networking	Killer Wireless-AC 1535 802.11 a/g/b/n/ac
Connectivity	3x USB 3.0, 1x HDMI, 1x Thunderbolt 3, Bluetooth 4.1, audio jack
Dimensions	0.7 inches (height), 13.6 inches (width), 9.3 inches (depth)
Weight	4.25lb

gamesradar+

One-stop destination for games, movies, TV, and more!

New Channels: Movies, TV and Cool Stuff!

www.gamesradar.com

Razer Ripsaw

Game capture the easy way

BOY, OH BOY, do we love streaming here in the *Maximum PC* office! Or, to be more precise, we love watching it. Not a day goes by without one of us casually watching the odd *Hearthstone* or *Magic: The Gathering* stream on Twitch, whether that's during lunch, or even sneakily during the day, while responding to emails. It's a passion, a hobby, and it's growing at a phenomenal rate. And as more and more of us tune in to watch our favorite live-streamers, it's only right that the number of live-streamers increases as well, right?

The thing is, it's never been an easy feat to get up and running. For those looking to get into streaming, until now it's always been an arduously complex setup process. You need the right system, preferably with a Core i7, an appropriate GPU, peripherals galore, and, of course, enough bandwidth to catapult those 1.8 million pixels you're pumping out every second into the stratosphere and down into your viewers' machines. That's not even taking into account the software side of things, such as OBS and XSplit.

WE ALL HAVE A VOICE

It doesn't need to be that complicated. Each of us has a voice, and each of us wants to be heard—that's the conclusion Razer has reached, at any rate. Which is why, after two years of development, we have the Razer Ripsaw. It's by no means the first capture device to hit the shelves, but it's one of the few that's targeted at providing a solution for the gamer who wants to record from anything to everything. Fancy streaming from your old GameCube or N64? You can do that (there's a component adaptor included). How about from your PC to another PC? Sure thing.

Now, we know many of you will be sitting there thinking, "What's the point? I already have a powerful enough PC to do that." Well, yes, that might be the case, but the beauty of the Ripsaw is that you can plug and play straight from one rig into another. You leave the idle system to render and stream the footage (or locally record it, whatever's your jam), and then have access to the entirety of your main rig's processing power solely for gaming. Think of it as what ShadowPlay originally did for GeForce, but far more advanced.

Setup is a fairly painless process. You simply plug an HDMI cable from your gaming system's graphics card into the Ripsaw, then a secondary (included) HDMI cable from the Ripsaw to your monitor. A USB cable goes from the Ripsaw to your streaming system, and job done. There are some fancy mixing features you can utilize at the front of the Ripsaw, but that's about it. Then it's just a case of downloading and installing Synapse on your streaming system, and you're good to go to use it as a video capture card.

During our time testing it, we found the Ripsaw was wonderfully consistent. The local recordings were crisp and sharp—60fps was a doddle. Fortunately for us, our gaming system comprised an Intel Core i5-4670K and a GTX 970, while the streaming system held at its heart a Core i7-6700K and 32GB of DDR4. Admittedly, that's probably not your average use scenario here, but even an Intel Core i3 should be more than capable of streaming 1080p at 60fps, bandwidth permitting of course.

Ultimately, using the Ripsaw makes for a surprisingly enjoyable experience. There were limitations in use, but they were mostly due to Twitch's delays. Being stuck having to use HDMI wasn't ideal, and having access to higher resolutions would also have been nice (1080p is your limit). While 1440p or 4K isn't easily accessible for the majority, having the option would have been a great way of future-proofing the Ripsaw. **–ZAK STOREY**

VERDICT
9

Razer Ripsaw

➕ **CHAINSAW** Great versatility; does exactly what it promises; affordable; well equipped.

➖ **RUSTY SAW** No options for higher resolution capture.

$180, www.razerzone.com

SPECIFICATIONS

Max Resolution	1080p @ 60fps
Interface	USB 3.0
Video/Audio Connectivity	HDMI/analog component
Separate Audio Inputs	3.5mm mic, 3.5mm aux
Dimensions	5.1x3.4x0.7 inches
Weight	6.4oz
Compatible Software	XSplit, OBS

X99 SERIES
DESIGNED BY ASUS
ASUS
X99-A II
FOXCONN
LGA2011-3
Crystal Sound
PCIEX16_1
PCIEX1_1

LEDs don't seem to be going away any time soon.

Asus X99-A II

A beautiful and necessary refresh

NEW CHIPS, new chips everywhere. Lovely, luscious chips. Broadwell-E is here. The Core i7-6950X has landed in all its deca-cored glory (see pg. 72), yet there's a few other processors in that wicked lineup of 14nm number-crunchers that are, perhaps, more interesting to the average fellow, as he swallows the day's sorrows down his local dive bar. Notably the i7-6800K. That six-cored, 12-thread processor makes X99 and HEDT systems more accessible to the masses than ever before. But what do you couple with a CPU like that?

How about the Asus X99-A II, a revision of Asus's entry-level X99 signature series motherboard? There are several notable differences between the original X99-A and this Broadwellian incarnation: you've got a new rear I/O cover; a new VRM heatsink design; advanced RGB LED lighting included along the top of the board, and on the PCIe slots; better fan control technology, including Q-Fan 4; a reinforced PCIe slot; electrostatic discharge protection for your RJ45 Ethernet; an additional 4-pin EPS power, to help balance out processor voltage load; and the addition of a U.2 connector, located just south of the SATA connectors.

That's a pretty hefty update, to say the least. As far as design goes, Asus has really nailed it when it comes to glitzing up one of the historically more dull components in your system. The rear I/O cover is a nice touch, and the clean style and reinvigorated heatsinks, pulled across from its Skylake signature series, work wonders on this entry-level HEDT mobo.

So, is she a performer? That depends entirely on how you configure it. By default, all Asus boards—certainly Skylake onward—have an included Asus Optimized CPU Ratio setting automatically enabled in the AI Tweaker section, buried deep within the BIOS. For those running purely vanilla chips, sans any BIOS tomfoolery, this tends to bump up the frequency by around 0.2GHz, meaning that, at stock, benchmark scores tend to be higher than those of competing motherboard manufacturers. However, keeping this enabled during overclocking quite dramatically reduces the overall performance output at higher voltages and frequencies.

As far as overclocking goes, we've always loved the extra effort Asus puts in to push that barrier higher. Let's face facts here: the X79 and X99 processors' default frequencies are always pretty sluggish, which is a shame when you consider just how ridiculous the potential is of the vast majority of these cores. The extra pins Asus has included within the socket are meant to help retain a more precise CPU VCore voltage during overclocking, meaning a more stable overclock overall. In our testing, we found this to absolutely be the case. Setting our VCore way up to 1.35V, and then running Cinebench as our load test, saw absolutely no drop or random variances at all, regardless of Vdrop.

FOR THE RECORD

Amazingly, we managed to get our trusty Core i7-5820K to clock up to an astounding 4.5GHz, and have it remain completely stable on only 1.375V. Impressive, to say the least, as it managed to break our own personal records in the process.

All in all, it's a sound update to the everyman's motherboard. For $5 extra, you get a bucketload of additional features, expandability, and options that were otherwise unavailable with Haswell-E's X99 mobos. That said, it's not without its flaws. For us, the biggest caveat this board has became apparent once we began work on our Build It feature (see pg. 66). Installing it into our mid-tower chassis was a nightmare—thanks to the CPU EPS power being top and center of the X99-A II, it meant we had to do some very ingenious pre-planning, just to get all the fan cables plugged in without a hitch. Although this placement is common in many of the high-end boards—as, let's face it, they're primarily designed to go into massive over-the-top production towers—the accessibility of the Core i7-6800K, coupled with the pricing and feature set of the X99-A II, is going to cause problems for those not willing to part with their otherwise midi-sized chassis. **–ZAK STOREY**

VERDICT
9

Asus X99-A II

⊕ **ASTOUNDING** Expandability; solid feature set; great upgrade over X99-A; subtle lighting; solid price.

⊖ **AWFUL** Location of CPU header.

$250, www.asus.com

SPECIFICATIONS

Chipset/Socket	X99/LGA 2011-3
Form Factor	ATX
Memory Support	128GB DDR4 @ 3,333MT/s
M.2/U.2 Support	1x M.2, 1x U.2
SATA Support	8x SATA 6Gb/s, 1x SATA Express
Max PCIe Support	3x PCIe 3.0 x16 (x8/x16/x8)
Rear I/O	4x USB 2.0, 4x USB 3.0

BENCHMARKS

	Asus X99-A II	MSI X99A Godlike Carbon Gaming
Cinebench R15 Multi-Threaded	**1,072**	1,022
TechARP's x264 HD 5.0.1	**23.47**	22.16
Memory Bandwidth	44.2	**44.8**
Shadow of Mordor 4K	**27**	**27**
Maximum Overclock Achieved	**4.5GHz**	4.4GHz
Cinebench R15 @ OC	1,293	**1,338**
Power Draw Idle	74	**72**
Power Draw Peak	355	**353**

Best scores are in bold. All benchmarks performed with an Intel Core i7-5820K, 32GB of DDR4 2400 (4x 8GB), GeForce GTX 980, and a Samsung 850 Evo 500GB.

Philips BDM4350UC

Another 4K HDTV in PC-monitor drag? Not quite...

BUYING A NEW HDTV? Then you'd be crazy not to pick up a 4K-capable screen. 4K HDTVs are now so cheap, they're giving 'em away in boxes of Cheerios. Well, almost. But does it necessarily follow that a big 4K screen makes sense for your PC?

It's certainly a tempting proposition to hook up a 4K TV to your PC for cheap. But 4K TVs don't necessarily make for good PC monitors. Early 4K TVs juddered along at 30Hz when connected to a PC. That's been solved with more recent screens, thanks to the addition of HDMI 2.0 and support for 60Hz refresh at 4K resolutions. But problems remain.

For starters, HDTV panels tend to be of the VA variety, in terms of panel. The net result is uber-saturated colors, which is great for an HDTV but less suitable for PCs, where accuracy is at a premium. Input lag and signal processing anomalies thrown up by the cheap electronics used in affordable 4K TVs only make matters worse.

With all that in mind, what to make of the new Philips BDM4350UC? First impressions are unsettling. At 43 inches and with fixed HDTV-style legs, rather than a stand with some kind of adjustability, the thing screams "HDTV." Then you spot that the panel tech is IPS, rather than VA, and has a full complement of video inputs, including DisplayPort, and it looks a lot more promising.

Fire her up, and the basic quality of that huge IPS panel is obvious enough. Philips, of course, already offers a 40-inch HDTV-derived 4K monitor in the BDM4065UC. But that model uses a VA panel, and the difference is marked. The BDM4350UC's colors are much more natural. We're also pleased to note that the extra three inches haven't detracted tangibly from sharpness or clarity.

Sure, it's the same 3840x2160 pixel grid as its 40-inch sibling, but the 102ppi is still only marginally worse than a 27-inch monitor with a 2560x1440 native resolution. With a rated response time of 5ms, the BDM4350UC is reasonably rapid, too. From here, however, the screen turns a little sour.

For starters, the huge scale of the panel puts a serious premium on viewing angles when used as a PC monitor. You sit much closer than you would when using such a large panel as a TV. That means the edges of the display are not only at quite an oblique angle, but also at a dramatically different angle to the center of the panel. The upshot is a noticeable drop off in brightness in the corners of the screen.

LAGGING BEHIND

We noticed just a little input lag, too. It's not a major issue—nothing like as bad as seen on those notoriously laggy early PVA monitors from around a decade ago—but it will be enough to bother fans of hair-trigger online shooters. There's also some slightly odd image borkiness, which initially looks like plain old banding, but is more likely signal interference associated with the image processing electronics. This is something that the BDM4350UC's 40-inch sibling also suffers from, though in a subtly different manner.

All of which makes for a mixed result for the new Philips BDM4350UC. The glories of the 43-inch IPS panel are undeniable. 4K is a beautiful thing on such a huge, high-quality screen. With that, however, come issues that would be hard to swallow on a $150 panel, let alone something nearer $1,000. But if you understand the issues, and think you can live with them, then we are happy to give this panel a qualified thumbs up. **–JEREMY LAIRD**

VERDICT
7

Philips BDM4350UC

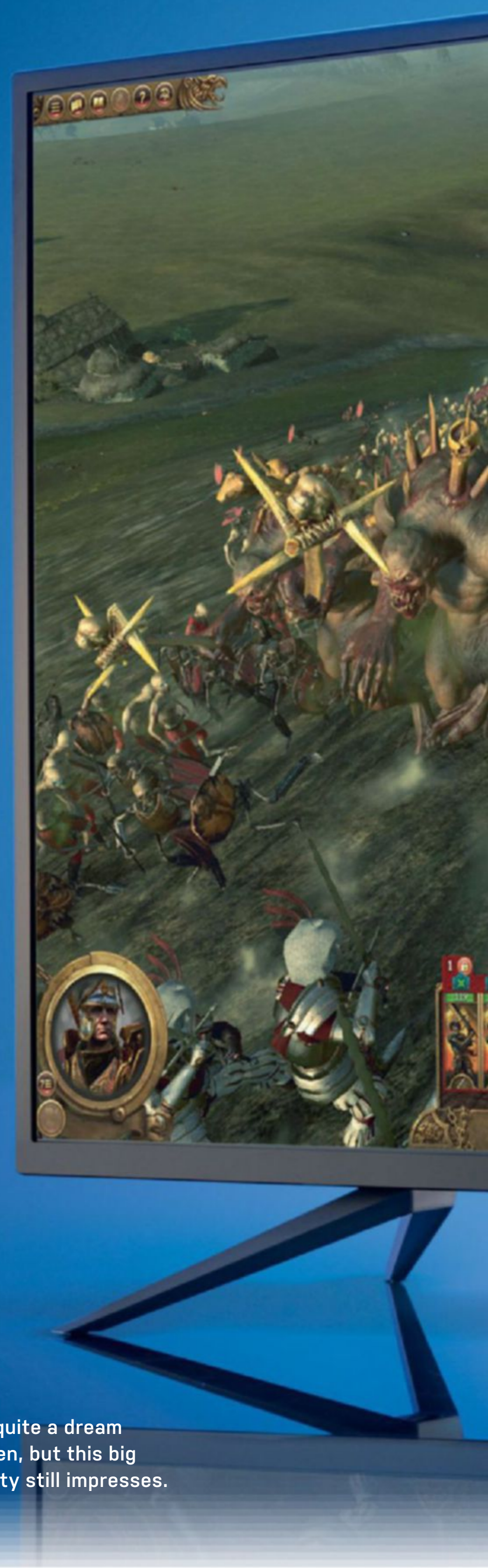
⊞ OSCAR-WORTHY Huge scale; gorgeous IPS panel; proper collection of inputs.

⊟ GOLDEN RASPBERRY So big that viewing angles are an issue; some minor image quality anomalies; fixed stand.

$799, www.usa.philips.com

SPECIFICATIONS

Panel Size	43-inch
Native Resolution	3840x2160
Panel Type	IPS
Max Refresh	60Hz
Pixel Response	5ms
Contrast	1,200:1
Inputs	2x DisplayPort, HDMI 2.0, 2x MHL
VESA Mount	200x200mm
Warranty	Two years



Not quite a dream screen, but this big beauty still impresses.

PHILIPS

Oculus Rift

First doesn't necessarily mean best

FOR THE LAST THREE YEARS, the promise of VR has been bold, and nothing short of a paradigm shift in how we interact with technology. For Oculus, this is presumably just the beginning, the first step on a long road. For game developers, too, this is the starting line of a race to design titles fundamentally unlike anything we've played before. Ultimately, however, the games and technology available at the start of this journey struggle to keep you in the headset for more than a few minutes at a time.

Oculus has designed its setup process to be as simple as possible. A single cable reaches out of the headset, before splitting into both HDMI and USB. The software is an always-on Windows service, utilizing the Rift's headset light sensor to detect when you've put it on, at which point it launches the Oculus Home software. Home is easy to use with the included remote or Xbox controller, with a simple library setup and large thumbnails for games.

Unfortunately, at launch, the software can only install games to the C:\ drive, an antiquated requirement that Oculus is aware of and will hopefully fix in the near future. As far as games go, the Oculus Rift's 30-strong launch lineup contains quite a few ports of simple games from the GearVR's library. Of those 30 games, many are enhanced by the perk of virtual reality. *BlazeRush's* miniature cars take on a charming toy-like quality; *Radial-G's* gravity-bending *F-Zero*-style racing becomes thrilling and intense (and stomach-churning if you're at all prone to motion sickness); *Pinball FX2* feels much closer to playing a real pinball table in VR than on a TV. But VR doesn't feel essential for any of these games. The one exception is *Chronos*, which draws a bit from classic *Resident Evil* and a bit from modern adventure games in the *Dark Souls* vein. It barely uses VR, with static camera angles, a third-person perspective, and genre-typical exploration and difficult combat. But the atmospheric touches in *Chronos* are top-notch.

FACE FACTS

The Rift weighs 470 grams, but a good chunk of that resides in the rigid plastic arms and headphones. Although heavy, they help support the front part of the headset and make it surprisingly easy to put on and take off. The front ends of the rubber strap slide into the arms at the front of the Rift, and are easily adjustable back and forth to conform to the size of your head. The one flaw in the Rift's design is the padded facerest. It's not uncomfortable, but it does leave an unsightly ring around your face after a few minutes of wear—far less comfortable than the Vive's soft cushion material.

As for viewing experience, the Rift ships with a pair of 1080x1200 OLED displays, bright enough and dense enough to avoid that pixelated look. The gaps are still there, but easy to look past when immersed. The flat displays become three dimensional thanks to a pair of hybrid fresnel lenses, and everything runs at a smooth 90Hz. The Rift isn't without its problems, however. Overall, the vertical FOV feels smaller than the Vive's, which is disappointing—the edges of bright in-game objects, and especially text, produce a distracting shimmering effect, pulling you out of that immersive environment.

The Oculus Rift is both a headset and a platform for playing games in a new way—hardware, software, and experience, all rolled into one. Compared to Oculus's prototypes, the Rift is a triumph of engineering—light and comfortable, with better optics. But the screen and lens technology still stand in the way of fully buying into these new virtual worlds, and that will be the case for the lifetime of this piece of hardware. The shortage of compelling games is, hopefully, a more short-term problem. The pool of options is wide, but shallow, and for now, the experience of using the Rift without motion-tracked Touch controllers (which are coming separately later this year) disappoints. **–WES FENLON**

VERDICT **7**

Oculus Rift

⊞ **CYCLOPS** Virtual reality; immersive; well designed; the one that began it all.

⊟ **DR OCULUS** Lack of stimulating titles; no VR controllers; price; screen not as good as Vive.

$599, www.oculus.com

SPECIFICATIONS

Combined Resolution	2160x1200
Pixel Density	456ppi
Field of View	110 degrees
Refresh Rate	90Hz
Lens Type	Hybrid fresnel
Sensors	Accelerometer, gyroscope, magnetometer
Headphones	Integrated
Weight	470g

HTC Vive

Almost nailed it

THE VIVE BOLDLY PROJECTS confidence that this is what VR should be like. That it will feel real, and that the future has finally arrived. Right now, the HTC Vive is the best way to experience virtual reality. This is the VR you've been waiting for. It is occasionally hindered by the growing pains of emergent hardware, but those issues don't stop the Vive from enabling new ways of playing and being immersed in games.

The Vive differentiates itself from the Oculus and other VR systems presently available with two features: room-scale games, and a pair of motion-tracked controllers. The hardware itself works just fine sitting down and using a gamepad, but its two laser-emitting Lighthouse base stations let you walk around in a space of approximately 4x3 meters. All this hardware leads to a far more complex setup process than the Oculus Rift. Both controllers come with their own micro-USB charging cables and plugs, the two Lighthouse stations have their own power sources, and there's a cable breakout box to stop you from yanking over your PC if you accidentally step on the Vive's cable. Despite this giant pile of hardware, the Vive setup process is surprisingly easy. Plugging in the headset involves more cables—separate HDMI and USB cables from the breakout box to the PC, and cables from the headset to the breakout box—but it's a fairly simple process.

Unlike Oculus Home—a dashboard built from the ground up for VR—Valve has repurposed its Big Picture Mode interface for SteamVR. This makes it fairly easy to navigate your library and the store. As with the Oculus Rift, many of the launch games on the HTC Vive are demos and short experiences that make for compelling introductions to VR. The short film *The Rose and I* is incredibly simple, yet standing inside it and watching it play out is surprisingly moving. *Space Pirate Trainer* takes the basics of an '80s arcade shooter and makes it an agile VR experience that sends you crouching to the floor and dodging incoming lasers in slow motion, like you're in *The Matrix. Audioshield* has you punching music to the beat instead of tapping buttons.

The HTC Vive is not an elegant headset. While the Rift evolved through many prototypes into a slick, light headset built to woo the mass market, the Vive looks much the same as it did when it was unveiled in 2015. It weighs noticeably more than the Rift (555 grams versus 470 grams), and feels more cumbersome. It's held on your head with elastic straps, unlike the Rift's semi-firm rubber, which gives it more rigid support, and it tends to rest some of its weight on the bridge of your nose.

GRIPPING STUFF

The HTC Vive's controllers make all the difference. They're shaped like wands, with circular tracking arrays mounted on top, and they're elegantly simple in terms of inputs. There's one trigger, typically used to activate menus and "grab" objects; a trackpad, which can be divided up into multiple buttons or inputs by developers; a plethora of small buttons above and below the trackpad to serve as menu buttons; and a squeezable grip under your palm for one more extra input.

Like the Rift, the HTC Vive uses dual 1080x1200 pixel displays, which are high resolution enough to make the "screen door" pixel density issue of prior iterations mostly a thing of the past. The 90Hz refresh rate, coupled with the Vive's extremely accurate positional tracking, does a fantastic job of preventing VR motion sickness. The field of view, although not dramatically bigger than the Rift's, is a different shape, and feels like a larger window into VR, with far more vertical space to play with.

Ultimately, the weight, straps, and lack of integrated audio in the Vive are all disappointing elements of its hardware design. There are compromises here that you shouldn't have to make for 800 bucks. And yet the experiences it produces are exceptional. Developers aren't yet forging incredible new ground in VR, designing genres that were never possible or thought of before, but the experiences they are already delivering feel fundamentally very different indeed. **–WES FENLON**

VERDICT

8

HTC Vive

⊞ **ALIVE** Superior FOV; better game support; controllers; full-room VR.

⊟ **CONTRIVED** Weight; lack of integrated audio; price.

$799, www.htcvive.com

SPECIFICATIONS

Combined Resolution	2160x1200
Pixel Density	447ppi
Field of View	110 degrees
Refresh Rate	90Hz
Lens Type	Hybrid fresnel
Sensors	Accelerometer, gyroscope, laser position sensor
Headphones	None
Weight	555g

Corsair K70 RGB RapidFire

Exclusive switches increase speed but reduce clicks

ANOTHER MONTH, another mechanical keyboard. There are so many on the market at the moment that it can be hard to distinguish one from another. The K70 RapidFire has something you won't find anywhere else, however: its switches.

Those switches are the new Cherry MX Speed models, exclusive to Corsair for now, which answer the call from about 1 percent of the PC gaming universe for keyboards that respond more quickly. We're at the stage of dealing with edge cases here, with an actuation point that's only 1.2mm down, and needing a lower amount of force to reach that point. This may well speed up your use of the keyboard slightly, but it sucks some of the fun out of using it, too.

You see, one of the best things about a mechanical keyboard is the feel as those keys go down. There's the noise, too, of course, which should be enough to elicit complaints from someone trying to watch *Game of Thrones* in the next room; enough to be sure you're using your keyboard of choice, even though you're wearing over-ear headphones. Last month's BlackWidow X Chroma, using Razer's own switches, made a glorious noise. The K70 RapidFire, while still clearly a mechanical keyboard, isn't nearly so satisfying. Being linear switches, the keys slide down as though lubricated, robbing them of that all-important feel as they pass the activation point. But hey—it's fast.

On top of the switches sit the keys, and they have a gratifyingly large character window on top of them, the better to let through the colored lighting that you can make flash and coruscate with the bundled software. Looking at the keyboard from the front, the keys seem to sit very high on their switches—odd for something selling itself on its shallow depth—and look as though they could be popped off easily, perhaps even accidentally. They do come off easily, and even wobble a bit when mounted properly, but we didn't once manage to knock one off without specifically trying. A couple of sets of replacement keys come in the box—one set for FPS games, and another for MOBAs, highlighting the important keys for their respective genre, in case you forget where they are.

The space bar has a textured surface, reminiscent of Corsair's Strafe keyboards, so your thumbs don't slip off it; its pattern of raised bumps is rather like the metal flooring used for fire escapes. Elsewhere, you'll find the always-welcome Windows Key Lock switch, some media playback controls, and a metal volume roller. There's a useful USB port on the back, which certainly beats having to fumble round the back of your case (although, sadly, it's not USB 3.0). A BIOS switch adjusts the polling rate if the K70's super speed means it refuses to work with your motherboard, and the keyboard has the usual rollover and anti-ghosting tech to ensure your inputs don't get garbled.

STRONG POINT

Underneath all that, the frame is aircraft-grade aluminum, apparently designed to survive a lifetime—it doesn't say whose—of keystrokes. We're not sure that metal frames breaking from being typed on is a big problem, having failed to put so much as a fingertip through a keyboard in 30 years of using them, but perhaps we don't have the over-developed extensor tendons of a pro *Counter-Strike* player.

Keyboards are marketed as long-life products, so we find it odd that they turn up in our office so often. If you're already using one, and it's not falling apart, there's little reason to upgrade. Keyboard switches are very much a matter of personal preference, but the feel of these linear switches won't be for everyone, and the extra speed gains cleverly engineered by Cherry will benefit even fewer. However, if you're upgrading from a membrane or chiclet model, try this out. You might just become the fastest Glock in the monastery. –**IAN EVENDEN**

VERDICT 8

Corsair K70 RGB RapidFire

+ RAPID Enables quick keystrokes; sturdy build; USB pass-through.

− VAPID Unsatisfying feel, thanks to the linear switches.

$170, www.corsair.com

SPECIFICATIONS

Switch Type	Cherry MX Speed
Form Factor	Standard
Media Keys	Dedicated
Macro Keys	None
LEDs	Full 16.8 million color
N Key Rollover	100% anti-ghosting
Pass-Through	1x USB 2.0
Dimensions	17.2x6.5x1.5 inches
Warranty	Two years

Corsair M65 Pro RGB FPS Gaming

The king of the squeakers?

YOU KNOW, mice are one of the most subjective products on the planet. As a device, they're such an odd concept: Although highly precise, accurate, and incredibly useful, we're never actually taught how to use one. Ironic, when you consider how we write, how we speak, and even how we type. Because of that, you tend to get as many different styles of grip as physics allow, and so-called bad habits have become entire techniques of mouse usage. So, designing any one mouse to satisfy all of those different niches, all those different people, is a challenge.

The M65 lineup from Corsair has always produced an eye-catching mouse. The aluminum chassis presiding over the whole sleek affair glistens on the undercarriage of this well-crafted pixel-pusher. The 0.7 ounces of adjustable weight locked in place underneath help you configure the mouse to exactly the right heft for you. The finish, unlike that of its elderly cousins, is now split—the thumb and pinky side rests have a hint of sandblasted elegance, resisting grease and sweaty fingers, while the top features a gorgeous soft-touch rubber-coated finish.

BIGFOOT? IS THAT YOU?

As far as feel goes, this mouse is right up there. It's definitely on the larger side of things for a mouse, certainly in contrast to this reviewer's small hands, but the reality is that it still lends itself to a comfortable palm grip. It's not long but wide in its overall footprint. That's not to say those fingertip and claw grip users among you will be out of luck, as it's chunky enough and wide-spread enough to make that style achievable, too. Almost the perfect mouse then, surely? Well, it's an odd experience. The way your hand folds to this mouse is reassuringly open; nowhere near as grippy and embracing as Mionix's legendary Castor, but then it doesn't need that—they're two very different mice, aimed at providing a high degree of comfort in two very different styles.

When it comes to utility, the M65 Pro loses out to the likes of the more button-heavy competition. In reality, short of the obvious buttons, you only get those old-school forward and back buttons, followed by a shift hold reduced-DPI button, flatteringly adorned with a crosshair logo, so you remember that this button is for lining up the most perfect headshot possible. Honestly, though, for the likes of our audience, and us here in the office, the M65 Pro would be damn near perfect if this one button was removed. Add another slimline button to the opposite side, and it would be flawless—just enough balanced utility for the everyday user, with sufficient class to match it to the original Corsair K70 Keyboard from way back when.

What is nice about this little beauty is that we're finally stepping away from laser sensors in favor of more precise, high-range optical sensors. Zero jitter, zero interpolation at higher DPI settings—surface accuracy with optical sensors is phenomenal, and it's something that we're really glad to see becoming the norm when it comes to good mouse design. How on earth they managed to achieve 12,000 dpi with an optical sensor is beyond us, but props to Pixart Technologies for managing it. Maybe one day, when we're all running 8K screens, it'll be necessary, but we're still not really convinced that it's required just yet.

The M65 Pro reminds us exactly what catapulted Corsair to greatness to begin with. The Obsidian line of cases, the Dominator Platinums, the K70 Vengeance mechanical keyboard. It's all there. You've got the aluminum concepts embedded inside its beautiful frame, that soft-touch finish on the top, sandblasted on the side, that pleasing degree of utility via the three buttons, a unique level of comfort, and the subtle LEDs, lines, and curves that together separate a good product from just a garish one. **–ZAK STOREY**

VERDICT
9
KICK ASS!

Corsair M65 Pro RGB FPS Gaming

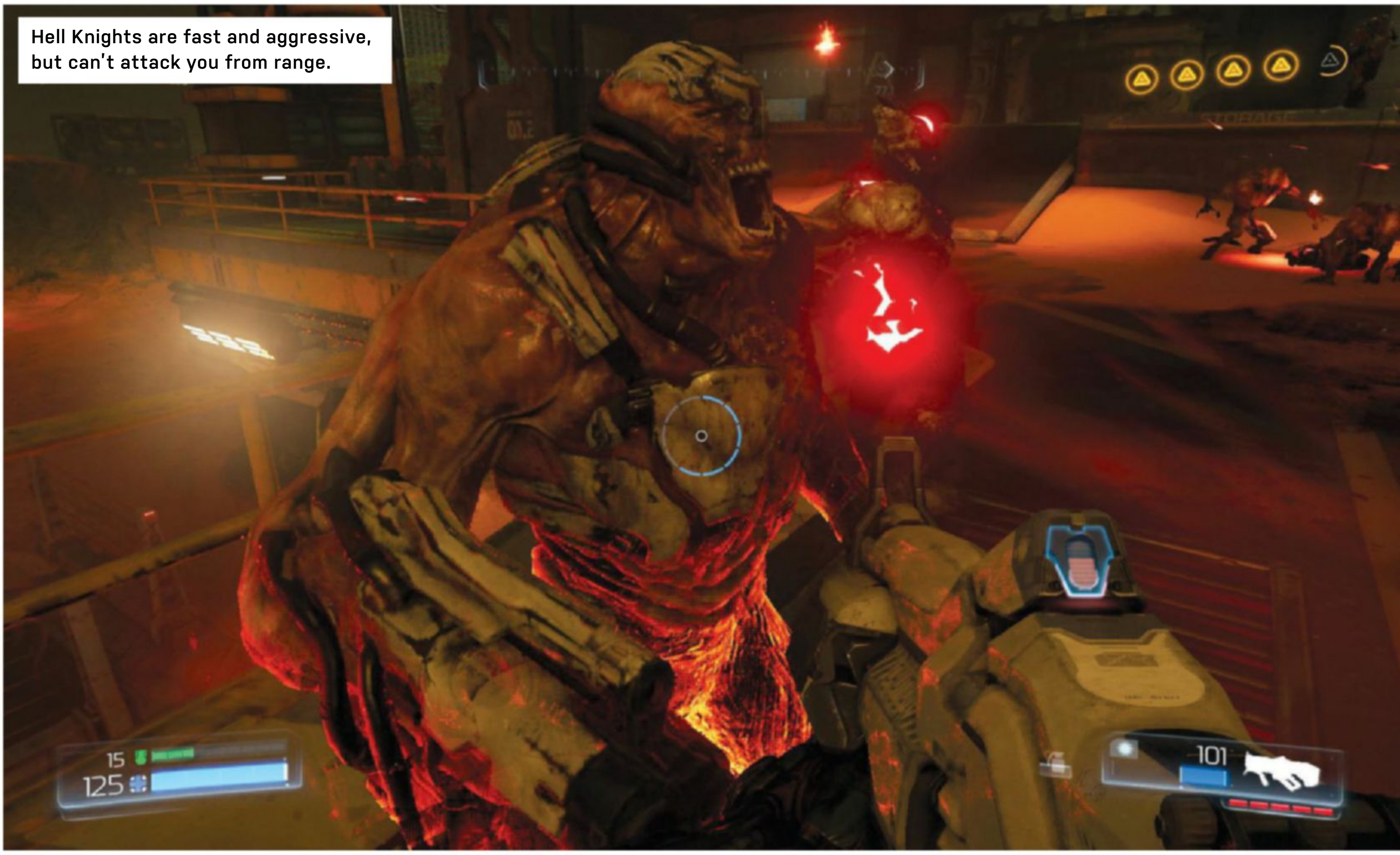
⊞ **PROS** Soft-touch finish; elegant, simple, and sophisticated; adjustable weight; CUE software; price.

⊟ **CONS** Silly DPI button; needs one more button.

$60, www.corsair.com

SPECIFICATIONS

Sensor	Optical
Sensitivity	100–12,000 dpi
Sensor Model	Pixart PWM336x
Polling Rate	125Hz, 250Hz, 500Hz, 1,000Hz
Programmable Buttons	8
LEDs	Three zone 16.8 million color
Cable Length	6 feet
Weight	4.0–4.7oz



Hell Knights are fast and aggressive, but can't attack you from range.

Doom

Respecting the past while raising a fresh kind of hell

GAMING IS STILL a fairly young artform. As a result, it has a difficult relationship with its own history. No one's going to remake *Breakout* in Unreal Engine 4 and charge $60 for it, but 23-year-old game mechanics can still be repackaged with a few updates, a massive graphical overhaul, and a new soundtrack from the crunchier genres of metal.

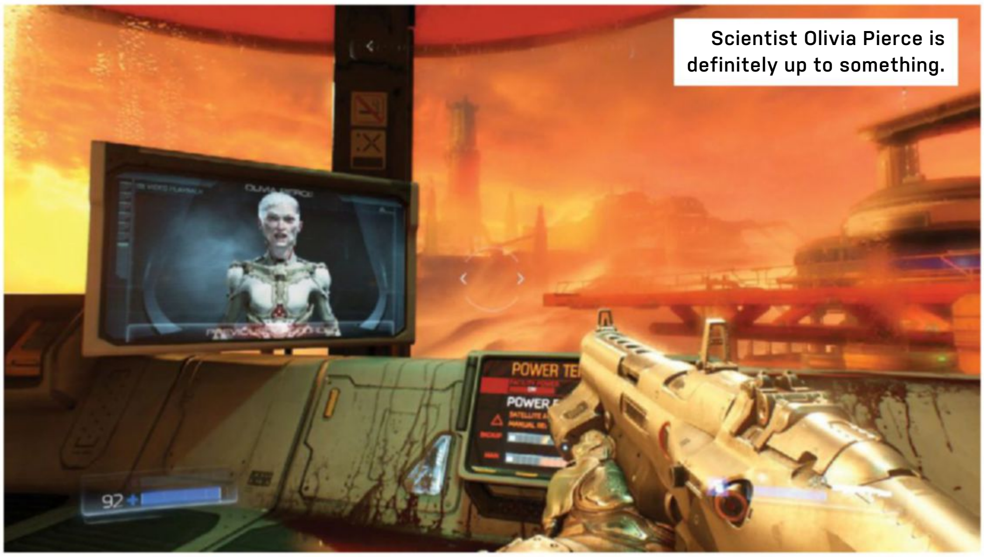
Yes, it's still *Doom.* Red keys still open red doors, and there's something nasty in the woodshed. The game that ran as a 320x240 slideshow on a 33MHz 386, but which you persevered with because it was so frickin' cool, and these days takes up less disk space (2.3Mb) than the average web page. The previous game in the series, the survival-horror flavored *Doom 3,* is 12 years old, recommended 128Mb of video memory, and ran on the original Xbox. *Doom 2016* brings things right up to date, with the latest version of the id Tech engine, and a suitable bump in recommended specs, but leaves the gameplay rooted solidly in the '90s.

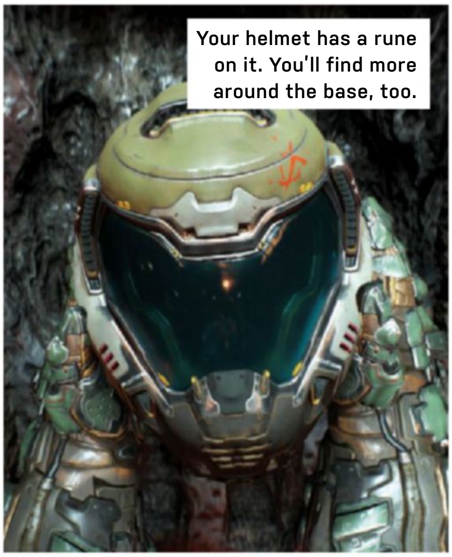
This time around, the world's worst renewable energy scheme has attracted the ire of Hell. We're not sure if this is a comment on future energy security or not, but a Tesla Powerwall would surely have been a lot less bother.

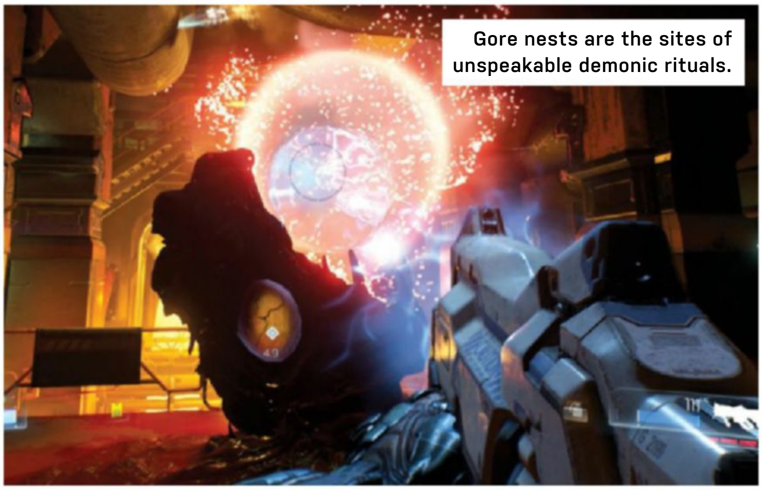
Once again Mars has been chosen as the location. This leads to a samey industrial look to the early levels, and the game inherits *Rage's* static world, a hallmark of previous id Techs' megatexturing, where only enemies and explosive barrels have been imbued with physics properties. Fire your shotgun into a slumped body or pile of oxygen cylinders, and they don't react in any way, apart from during scripted sequences when you open airlocks. There are plenty of smoke and particle effects, and entrails strung from the ceiling at least swing in a realistic fashion. Heading into Hell adds a splash of red to the proceedings, and a dash of imagination to the corridors and arenas—although it never really lets itself loose; possibly a condition of the engine.

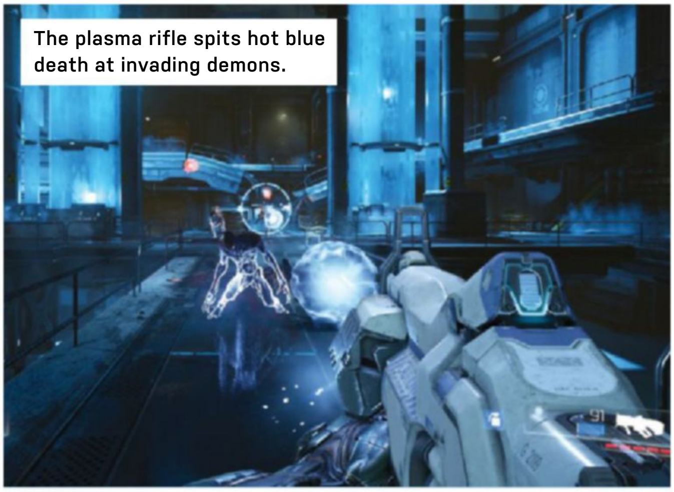
But what a marvelous thing id Tech 6 is. Given the ridiculous speed at which Doomguy now moves—he's faster than just about every demon in the game, something you're encouraged to make use of—the engine has a lot to keep up with, and this explains the enclosed arenas and demons that come in efficient waves, rather than all at once. We didn't notice any poor textures or frame rate chugging while playing on ultra settings, however, and there are special graphics options for those blessed with 5GB-plus of video memory.

As for the bad guys, every favorite from the series is back in one way or another, and some of them are a joy to unload heavy ordnance into, but can feel wasted thanks to the game's tendency to funnel you into arena battles, where you're locked in and can't leave until you've shot everything. When a game's idea of AI is for the monsters to either run at you or hang back and open fire, this can get stale quite quickly. We perhaps shouldn't expect demonic hellspawn to have much in the way of self-preservation instincts, but a little bit of flanking or fire avoidance, beyond climbing a pillar or jumping on a box and continuing to shoot, would be nice. The exception to this is the possessed security guard, with his


Scientist Olivia Pierce is definitely up to something.


Your helmet has a rune on it. You'll find more around the base, too.


Gore nests are the sites of unspeakable demonic rituals.


The plasma rifle spits hot blue death at invading demons.

energy riot shield, who follows the tradition of all shieldeded enemies ever by being plain annoying to fight.

GLORY BE!

This season, the House of Carmack's demons are looking a lot more *Doom 3* than *Doom 2,* accessorizing a general gray and brown color scheme, with red fireballs, and at least one artificial leg. You'll actually get to see them this time, because the game has abandoned *Doom 3's* aggressive shadowing, and the new Glory Kills bring them right up to your face, before ripping their arm off and beating them with it.

These kills, which have been a touch controversial in certain areas of the *Doom* fanbase, add to the formula by making melee strikes that don't use the chainsaw or berserk pickup worthwhile, and precipitate a risk/reward choice by offering health packs in return. Get a bad guy in a position where he's stunned and flashing, then move in for a punch, and a gory scene plays out. It doesn't take long, barely interrupting the rhythm of combat, and there's a decent mix of head-smashing, jaw-ripping, and stomping (for which Doomguy regrows the legs he's missing for much of the game). Cannon-fodder enemies have been designed with this in mind, a useful top-up before you return to the larger blasphemous perversions of flesh and metal.

The other big additions are upgrades for both armor and weapons, adding additional fire modes and increasing your maximum health and ammo capacity. The arsenal (and presumably Doomguy's holdall) has been expanded, grenades are now present (weirdly, they recharge once thrown), and the chainsaw and BFG have moved to dedicated buttons, as befits their importance to the canon. There is a handful of multiplayer modes that play like *Quake,* and then there's Snapmap, a level design tool with which you can create areas with monsters, event triggers, and other game logic, before sharing them.

This may turn out to be where *Doom's* longevity lives, as despite secret areas and multiple difficulty levels, there's not a lot of replay value in the single-player game.

While not every game has to be *Deus Ex,* it's easy to look at *Doom* in 2016 as unsophisticated. There's a distinct lack of moral complexity, and no gray areas that aren't metal walls. Blasting and chainsawing your way through the infernal legions is still frickin' cool, however; the additions to the formula thoughtful, and the game's speed remarkable. Indeed, it would be wrong to call *Doom* one-note because there are two: you're either frantically shooting, or you're not. This reincarnation of *Doom* could be the cleverest dumb game we've played all year. –**IAN EVENDEN**

VERDICT 8

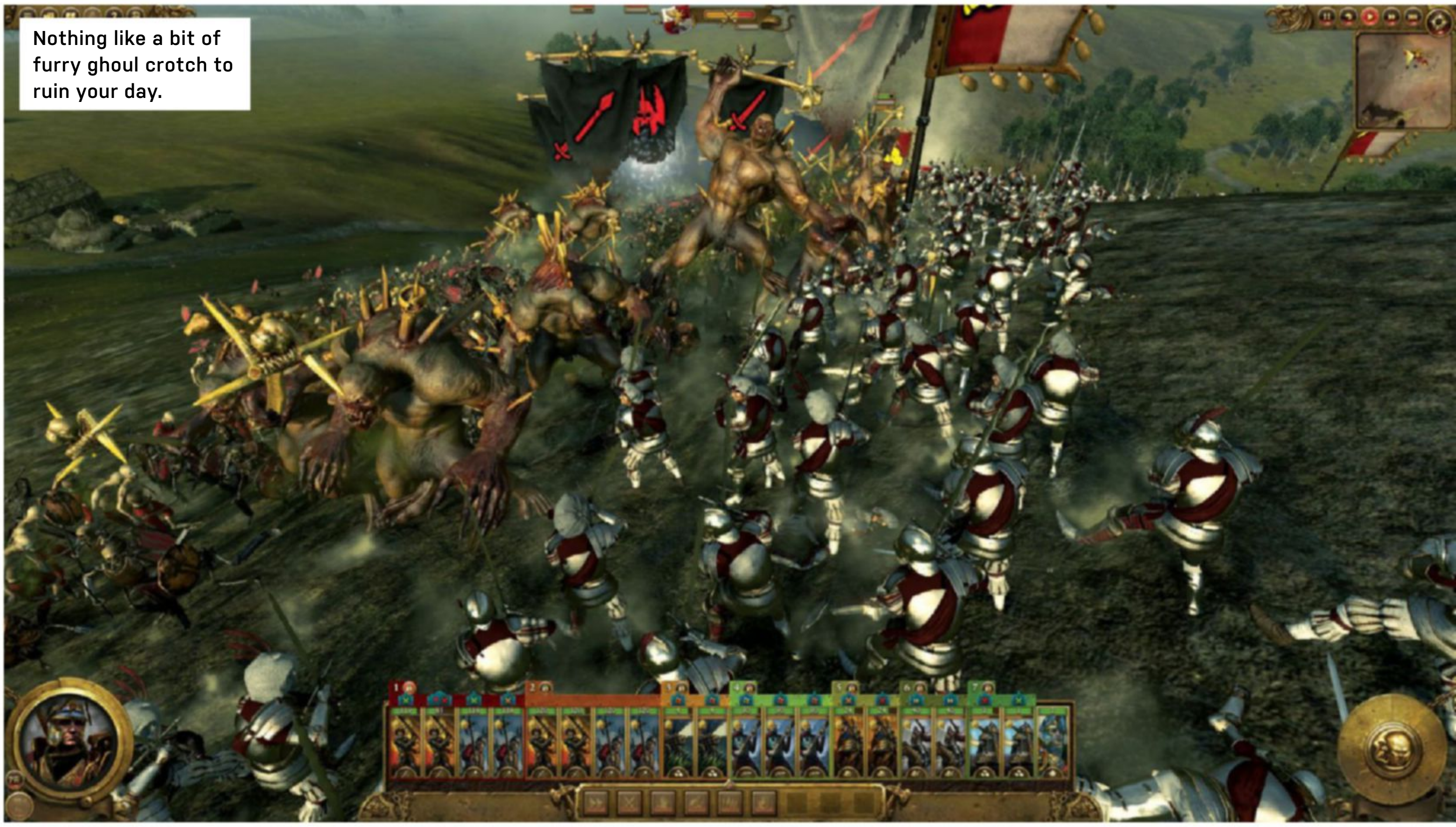
Doom

➕ **TITANIC** Speed, guns, gore, and demons—on Mars.

➖ **SATANIC** The same guns, the same gore, the same demons.

RECOMMENDED SPECS Intel Core i7-3770 or AMD FX-8350, 8GB RAM, Nvidia GTX 970 or AMD Radeon R9 290.

$60, www.doom.com, ESRB: M



Nothing like a bit of furry ghoul crotch to ruin your day.

Total War: Warhammer

A match made in heaven

SWORDS AND STEEL—that's what *Total War* has traditionally been witness to. The clashing of armies across the corpse-littered battlefields of our world. A world where history changes depending on the player's skill. Where Rome conquered all, the Samurai held on to Japan's sovereignty, and Napoleon became ruler of the largest empire this planet had ever seen.

Swords and steel—that's what it's always been. Until now. The clamor for a *Warhammer* spin-off has been heard ever since *Rome: Total War* first graced our screens all those years ago. A way to see the far-reaching fantasy armies of Games Workshop go toe to toe on the battlefields of their cursed apocalyptic world; a world so unlike our own. And, at last, we have it: the latest in the *Total War* franchise. A game unlike any other in the series.

So now that the heralds of the end times have signaled doom upon us all, we'd best start with the familiar. The integrity of any *Total War* game stems from its campaign mode, and *Total War: Warhammer* doesn't disappoint. You're presented with five factions to choose from: the versatile Empire, stout Dwarfs (not to be confused with Tolkien's dwarves), the undead Vampire Counts, the savage, marauding Greenskins, and the vast armies of corrupted Chaos Warriors (Bretonnia is available in custom battles, but not in the campaign just yet). Each faction is intricately unique, both in how they feel to play on the battlefield and how they operate on the campaign map.

TAKING SIDES

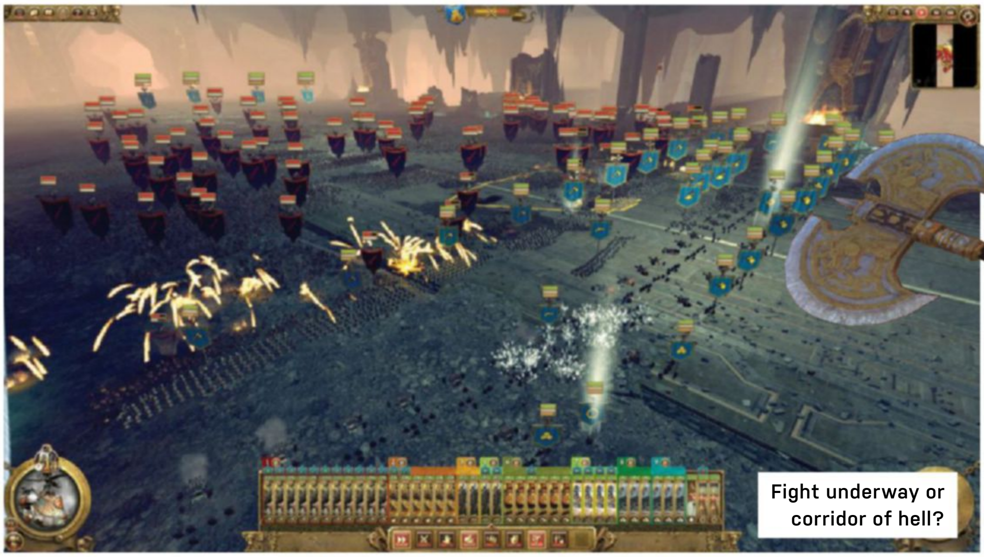
The Dwarfs shun magic, and don't take kindly to anyone trespassing upon their soil. Their intricate play style revolves around the Book of Grudges—any time an enemy faction raids your lands, attacks your cities, or tries to assassinate one of your lords, you're issued with a grudge, demanding you give those misbegotten swine their comeuppance. Too many unanswered grudges, and political instability becomes rife leading to civil war.

The Empire, on the other hand, has a far more traditional play style. There's no Book of Grudges here, but from the start, you're beleaguered by a fractured nation, surrounded on multiple fronts by both the Greenskins and civil rebellion. Not to mention the looming threat of Chaos.

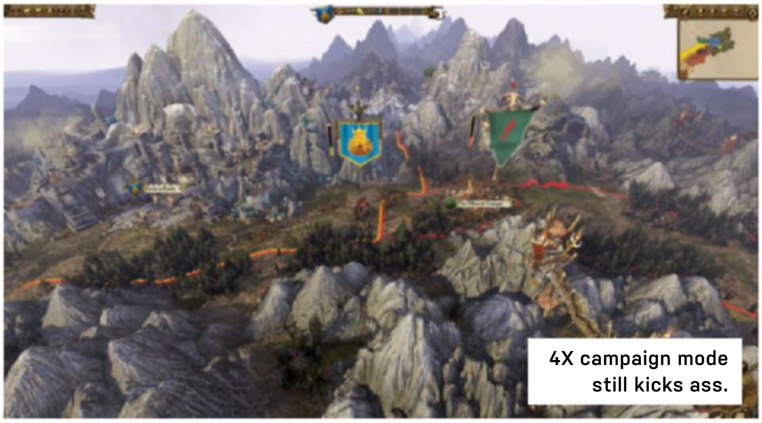
Speaking of the Greenskins, their economic strength is just a fraction of that of their more sophisticated neighbors. They rely heavily on raiding and fighting to maintain their dominance across the continent. In fact, they have a "fightiness" meter (yep), which requires them to destroy their enemies, or suffer attrition and losses at the hands of each other. Once the fightiness meter is high enough, they'll enter a state of "Waaagh!" with an identical separate army joining in the throes of combat for free.

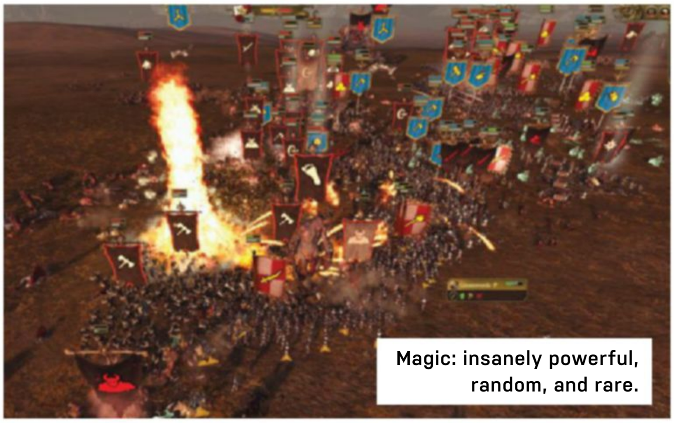
Finally there are the Vampire Counts. With a diverse unit roster, they rely predominantly on the spread of corruption to help secure safe passage for their forces. The higher the corruption, the more the enemy suffers, and the greater power the Vampire Counts have, raising the dead found in your own battle sites to bolster their forces.

Unlike every *Total War* game before it, *Warhammer* provides the player with a unique experience each time they start up a campaign. That's not to say it's perfect, though; there are missing elements. In particular, there's no squalor to manage, no more food supplies to maintain, and no more political corruption (granted, Chaos and Vampiric corruption work


Fight underway or corridor of hell?

Well someone's overcompensating.


4X campaign mode still kicks ass.


Magic: insanely powerful, random, and rare.

easily as well as a substitute here). On top of that, there are additional limitations in place to stop you from straying outside of *Warhammer* lore. For instance, as a Dwarf, you can only capture other dwarven or orcish settlements, and none from the Vampire Counts, the Empire, or Chaos. As the Empire, you can't take dwarven strongholds, and so on.

Battlefield combat, meanwhile, is all sorts of fun. Each faction fights in a unique manner befitting their history and stereotypes—strategies need to adept for each race. However, the biggest culture shock is what the *Warhammer* universe allows you to do. There's black powder, cannons, gyrocopters, giants, monster arachnids, tanks, archers, crossbows, swordsmen, demigryph knights, and the more traditional infantry that we're used to.

Then there are the legendary lords, which are vastly superior to generals of previous titles. These war leaders are like armies in their own right, capable of taking out multiple battalions by themselves. This adds intriguing strategical decisions: Do you go all-in and throw your general in, too, or hold back in a more traditional, old-school style of *Total War* play?

And there's magic. A powerful resource, generated slowly over time (or quickly, depending on the flow of the Winds of Magic), which allows your magi to cast spells capable of destroying the hardiest of units in a ball of fire, or even raising the dead to fight again. Incredibly strong, but often intensely volatile.

The biggest change, however, comes to siege battles. One wall or two? That's your choice. You no longer have access to all four sides, and, in reality, that's no bad thing. Cast your mind back—when did you ever use more than two? Seriously. It's just unnecessary. Now the walls are larger, the towers far more powerful, and the siege weapons far less effective. Holding the walls and the gate is vital to securing victory, and that's what sieges have turned into. It's great fun. Couple that with the vast selection of forces, and battles feel alive—incredible, intense, and engaging.

Graphically, the game is stunning. The designers have really gone to town, bringing the feel of *Warhammer* into the *Total War* universe. It runs smoothly on a range of hardware too.

The gameplay elements are well established and incredibly intuitive. The complexity is there for those who need it, yet it's accessible—easy to get into for those who are new to the *Total War* experience—and incredibly replayable. Yet, at the same time, it still feels like a beta; having access to only five races in campaign (six in custom battles) feels a bit narrow.

Fortunately, Creative Assembly has announced it will be releasing "FreeLC" over the course of the next year or so, to include more of the factions found in Warhammer Fantasy. Until then, you're stuck with this wily bunch. It's a beautiful change of pace—if you're a fan of either the *Total War* or the *Warhammer* franchises, you'll be in heaven. **–ZAK STOREY**

VERDICT

9

Total War: Warhammer

+ TOTAL WAAAGH! Beautiful graphics; intuitive campaign; highly replayable; unique races; great fun.

– BOREHAMMER Campaign elements absent; custom battles need expanding.

RECOMMENDED SPECS Intel Core i5-4570 3.2GHz, 8GB RAM, AMD Radeon R9 290X or Nvidia GeForce GTX 760.

$60, www.totalwar.com, ESRB: Teen

LAB NOTES

JARRED WALTON, SENIOR EDITOR

Pascal Isn't Done, Not By a Long Shot

GTX 1080 is awesome, but Nvidia is holding back

WE'VE KNOWN ABOUT Pascal for what seems like ages, and after five years of 28nm, GPUs finally have a new process node. Nvidia has already launched its GTX 1080 (reviewed on pg. 74), with GTX 1070 coming soon, both using the company's GP104 architecture. The GTX 1080 is a beast that has devoured all contenders—just look at the bones! But while we're suitably impressed, this is definitely not the biggest GPU that Nvidia could make.

That title currently goes to GP100, which is available in the Tesla P100. Except it's not really available as a stand-alone card; if you want GP100, you'll have to buy one of Nvidia's $129,000 DGX-1 servers. At least that will net you eight Tesla P100s, which means they're around $12,500 a pop.

As fast as GTX 1080 is, all you have to do is look at some of the specs of GP100 to guess where Nvidia will go next. GP104 has 7.2 billion transistors, a step down from the 8 billion transistors in the Titan X's GM200, but 16nm FinFET has brought higher clocks, a smaller chip, and lower prices. GP100, in contrast, goes big, with 15.3 billion transistors and a 610mm^2 die that's nearly twice the size of the GP104. It also packs 16GB of HMB2 memory, capable of 720GB/s, and FP64 runs at half the rate of FP32 (compared to 1/32 on GP104).

Will we see GP100 in a Titan or 1080 Ti card in the future? Perhaps. Or Nvidia could do a consumer card without the FP64 and HBM, but with more FP32 cores and 12GB GDDR5X memory. Whatever the company builds, though, it will certainly trounce our current darling, the GTX 1080.

What's better than GP104? Try the GP100.

ZAK STOREY

Staff Writer

Boy, am I excited about Pascal and Polaris! But it's not the performance increase that's ruffling my jammies, but something more obscure. I'm looking past the 16nm FinFET process, the GDDR5X, and the HBM2.0 heading our way to those tiny afterthoughts placed on the rear end of these processing powerhouses. Yep, I'm talking connection standards. Most notably DisplayPort 1.4. So what does it bring to the table that 1.2 couldn't? Well, 3840x2160 at 120Hz for starters. On top of that, resolutions as high as 8K, without the need for dual DisplayPort cables, or any of the awful bodging. The dream? A 28-inch 4K 120Hz HDR IPS panel. That's what I want to see this year.

ALEX CAMPBELL

Associate Editor

With the introduction of the GTX 1080, I've been thinking about something that's already a rarity: SLI. With the GTX 1080, Nvidia recommends that users don't go any higher than two-way SLI. While three-way SLI is still technically supported, it's not supported out of the box; you have to ask Nvidia for a code to enable three-way. This will make three-way SLI even more of a rarity than now, which begs the question: Who will need the extra PCIe x8 or x16 slots? Certainly, people can find ways to fill them, but for the enthusiast gaming PC crowd, it brings the default of the ATX form factor into question. To me, micro-ATX starts looking more attractive if two PCIe slots are all you'll ever need.

Editors' Picks:
Digital Discoveries

Tuan Nguyen, Editor-in-Chief, and Alan Dexter, Executive Editor switch on to the future

NETGEAR PROSAFE XS708E

Gigabit Ethernet is so dead. For me, anyway. If you do a lot of file transfers over a network, like I do, you might consider stepping up your network game—to 10Gb Ethernet. At these speeds, even the fastest SATA SSDs can't come close, since they top out at a theoretical 6Gb/s. When upgrading my home to 10GbE, I needed a switch that could manage the insane speeds. I picked Netgear's ProSAFE XS708E.

The problem with upgrading to 10Gb/s Ethernet is that everything in your infrastructure needs upgrading, too. Most consumer motherboards don't have anything faster than 1Gb/s Ethernet, and all consumer routers and switches top out at the same speed. All my machines had to be upgraded to 10GbE by using add-in network cards, and all the in-wall cabling had to be gutted as well; you have to upgrade to Cat6.

After all the setup was completed, and end-points on the network operating at 10GbE, the old switch came out and the new XS708E came in. Verdict? I'm never going back to standard gigabit speeds ever again. The XS708E is basically the cheapest 10GbE switch you can get. If you're interested in 900MB/s and faster transfer speeds, this is the way to go.

$850, www.netgear.com

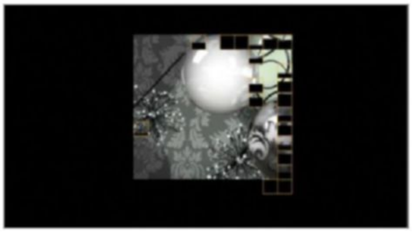
MAXON CINEBENCH R15

Sorry, I'm going to talk about benchmarking again. I did intend to look at a brilliant piece of hardware we've been playing with, but then Intel went and released Broadwell-E—sorry, I mean the Core i7-6950X (reviewed pg. 72)—and thus I find myself slack of jaw sitting in front of Cinebench. The reason for this mandible loosening may seem mundane, but having more little boxes than before spiraling their way to a ray-traced image is exciting. At least for this old hack.

Each of those rendering squares is powered by its own thread, you see. And this being the top-end Broadwell-E chip, it has no fewer than 20 threads, thanks to the HyperThreading of its 10 physical cores. It's akin to having 20 CPUs in your PC, each one beavering away on its own little task.

This is going to be the real challenge for developers—how to utilize these cores in a meaningful way. And with such a range of core counts, it's hard for developers to know how many cores to properly code for. The good news is that the minimum number of cores in modern chips is pretty much fixed at four—even Core i3s have four logical cores, thanks to HyperThreading. Even so, it's going to be some time before the 20-thread 6950X represents the norm.

Free, www.maxon.net



GEEK TESTED & APPROVED

NZXT Grid+ V2

SO, I'VE BEEN having problems with a motherboard in my home system, namely the Asus Z170i Pro Gaming. By any measure, it's a beautiful little board. It holds its overclocks like a champ, has plenty of expandability options, and generally looks killer with a touch of modding. My only gripe is the Q-Fan technology. At first, I could run the fans as low as 20 percent; however, after allowing Asus's Q-Fan optimizer to get a hold of them all, I'm now stuck at 40 percent, and no lower.

What's the solution? A dedicated USB fan controller. NZXT's GRID+ V2 was my first port of call. Support for up to eight fans, small form factor, snazzy design, and USB compatible, it's right up my street. Installation was relatively easy, although finding room in the already cramped water-cooled Manta was a challenge. NZXT includes two self-adhesive patches of Velcro alongside 10 or so long zip ties—every modder's best friend. Once you've found the perfect position, in reach of all your fans, it's simply a case of plugging in the Molex power and the micro-USB to USB header, and you're good to go.

NZXT's CAM software, although occasionally being a little buggy—only in terms of graphical UI—was very easy to configure. Having the option to name each fan (including the pump), and then set my own fan curves, was simple and straightforward. And being able to turn them off entirely, while idling on desktop, was a dream come true. Cheap, highly configurable, and damn snazzy—what's not to love? **–ZS**

$30, www.nzxt.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Trusted Motherboards
> Fan Cleaning
> Video Upgrades

Does Not Compute

When building a new computer, I use your reviews to help me make decisions. Typically, if the hardware in question is less than a nine, I steer clear. I have always trusted that your reviews are fair and consistent. When reading your May issue of motherboard reviews, you gave the MSI Tomahawk a nine, but for the same board in your March issue, you gave it an eight. The March issue says the board is a bit flimsy, and if using aftermarket cooling, you might want to steer clear. This is an important point, which the May issue doesn't mention. There are other differences, which I won't go into, but I find these conflicting reviews disturbing. How do you reconcile them? **–John Kirk**

STAFF WRITER ZAK STOREY RESPONDS: When we perform a group test, it's a great opportunity for us to get a lot of a similar products in to compare against each other. You may notice that in all our group tests, only one product ever receives a "Kick Ass" award. That's not to say there aren't any other products there that could score as highly to warrant the award, it's just that we need to ensure that it's obvious which one we recommend as the best.

In the case of the Tomahawk, I first looked at it in January, at which point it was one of the first Skylake boards we received aimed at budget builders. Upon further analysis, during the May group test, I identified that, generally, all the boards around that price point felt the same—the PCB thickness of the Tomahawk was comparable to, say, the Asus Maximus VIII Formula (although, to be fair, the Formula boasts a reinforced backplate/thermal armor, making it seem thicker). Taking into account the group test itself, and its competitors, the Tomahawk was, in my opinion, well worth the nine.

Spotlessly Cool

I was interested in the December issue's article on water coolers to see if anything was mentioned regarding the proper way to mount the fan/radiator—I didn't see what I was looking for. It's important to have the airflow so that it passes through the radiator first, then the fan—not the other way round. I've seen some installs where the fan draws air from inside the case, then directs it through the radiator and out. The problem is that dust, old Frito chips, horse hair, and anything else floating around inside the case is sucked into the fan and blown against the radiator, where it is trapped between the fan and the radiator. It doesn't take long for the fins to become clogged. You then have to remove the fan from the cooler to clean it. Arranging the flow so that the air passes through the radiator first allows for easy cleaning, as the dirty cooler surface is completely accessible. **–Ken St. John**

STAFF WRITER ZAK STOREY RESPONDS: You'll be glad to know that, last issue, we ran a tutorial discussing fan orientation and the varying types of pressure systems you can use in your case.

Concerning the correct orientation of fans, this depends on personal preference. For instance, I'll happily clean my PC out each weekend with a can of compressed air, then strip it down once a month or so for good measure.

However, I get that not everyone is that anal about cleanliness. But even then, in a modern chassis, as long as you use a predominantly positive pressure system (ensuring dust is pushed out of unfiltered areas of your case), you should rarely encounter problems to that degree, as almost all intake/exhaust areas of most modern cases come with dust filters. The positioning of your fan, especially with regard to cleaning, makes very little difference, short of where you're going to be dusting, because one side will inevitably pick up dust. I have a lot of friends who opt to take the fans off entirely, and instead clean the entire radiator out with compressed air.

Regardless, this is an argument that's been running as long as radiators have been inside PCs.

Singleton

A friend wants to upgrade, and I'd like your input. He was interested in dual video cards, but I've always gone for one top-end (cost issues aside, other than a two-to-four year upgrade cycle). My rationale for this is as follows: If you go for a dual card setup, you are generally looking at a longer term investment than a

↘ submit your questions to: comments@maximumpc.com single awesome card. I'm just estimating, but in two or three years, you get at least two process upgrades, one or two DirectX upgrades, and memory channel upgrades. If you go with one card, in two or three years, you can get another top-end card that will beat or match a dual card setup with the original card. Plus, you get all the tech improvements and possibly lower power consumption. **–Chad**

SENIOR EDITOR JARRED WALTON RESPONDS: We almost always recommend moving up to a faster single GPU before going SLI or CrossFire, as even in the best of times, running multiple video cards can encounter hiccups—particularly with new games, where it's often days or weeks after launch before you get a fully functional multi-GPU experience. But, if you're going high-end, once you hit GTX 980 Ti (which is only slightly slower than SLI GTX 970 on games that support SLI), there's nowhere to go but dual GPU—or even three-way if you don't mind even more problems. We mostly run three-way and four-way setups for fun and extreme performance, however—I would never recommend more than two GPUs unless you really enjoy being on the bleeding edge of technology.

I've known people who sell their used graphics card(s) to help finance an upgrade, and they can usually recover half of the initial price, sometimes more. If you're willing to upgrade every 12–18 months, older GPUs are still usually in demand (for SLI/CF), but you end up spending more. If you bought a GTX 780 at launch ($700), then sold it for $350 to upgrade to a GTX 980 Ti ($650), you'd have the fastest single GPU, but you've shelled out $1,000 (plus time and effort to sell the used card).

[NOW ONLINE]

DOOM'S "NIGHTMARE" GRAPHICS SETTING

You really have to hand it to id Software; if there's one thing it knows how to do well, it's doomed space marines killing demons on Mars. They're back again, and this fourth (depending on how you want to count) iteration comes decked out in the latest id Tech 6 engine. It's the best looking *Doom* to date, no doubt, but what sort of hardware do you need to run this beast? And what about the new "Nightmare" image quality setting? Read the full story, with our comparisons and benchmarks, online at http://bit.ly/1TgCDh0.

The better advice is to buy a good $300–$350 card and lower quality settings, as needed, for two years, before upgrading to a new GPU. If you're in it for the games, rarely do you need to run at anything more than medium-to-high quality to have a great experience.

Stick It to 'Em

Are there any gaming laptops, 15-inch, with pointing sticks? None of the current ThinkPads are well suited for gaming, and the only other pointing-stick-equipped laptops I see are workstation models. **–Shayne Hodge**

SENIOR EDITOR JARRED WALTON RESPONDS: I can't recall the last time I saw a gaming laptop with a pointing stick. Pointing sticks were popularized by ThinkPads, and spread to other business brands, but these days they're only found in business laptops and mobile workstations.

The Lenovo ThinkPad P50 has up to a Quadro M2000M, which is around the level of a GTX 950M—not super fast, but adequate for 1080p medium. The HP ZBook 15 G3 and Dell Precision are similar, and at a similar price ($2,000-plus). Dell's Latitude 5000 has up to an R7 M360, but that's pretty slow nowadays. As far as I know, your choices are to spend a bunch of money on a mobile workstation and get a Quadro with a pointing stick, or give up the pointing stick and go with a gaming notebook. Hope that helps.

Bit Off

In the article "Battle of the Cans" in the April 2016 issue, there is a mislabeled graphic. On page 33, there is a graphic that shows a sine wave and its digitized form. The caption reads "An analog waveform (pink) being encoded as a 16-bit digital signal (black)." The signal in the graphic only has 16 levels, zero through 15. This is a 4-bit signal, or $2^4 = 16$, not a 16-bit signal. A 16-bit signal has 65,536 signal levels, or $2^{16} = 65,536$. **–Igor A Vinograd**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: You're right. Showing all 65,546 levels would have been tricky, so for clarity we only showed the signal being encoded with 16 levels, but forgot to change the caption. The person responsible has been (digitally) reprimanded.

Virtual Desktops

Reading your Windows 10 feature (May 2016), item 3, I can't figure out how to do what you describe. I can show multiple desktops on the screen of one of my two monitors, but no icons are showing. So, how can you drag an icon to one of the windows? I checked Cnet and it says you can't. Hopefully, you know some secret way. **– Gary Smith**

CONTRIBUTING EDITOR NICK PEERS RESPONDS: When you create a new desktop, you switch to that desktop. If you roll your mouse over desktop one or press the left cursor key, you move back to that desktop, where you see the thumbnails of the applications you have open. From here, you should be able to drag them between the desktops.

This is how to move the applications between the various virtual desktops, although I suspect that you want to move the desktop icons between virtual desktops—unfortunately, you can't do this within Windows 10 itself. The closest thing we can think of to help you here would be Fences from Stardock, which would enable you to organize your icons better, but even that might not be quite what you want.

YOUR COMPLETE GUIDE TO THE PLANET'S MOST COMPLEX MACHINE

DISCOVER SCIENCE SERIES
Secrets of the Human Body
148 PACKED PAGES
INSIDE
• Build the perfect brain
• What lives in your guts?
• How implants can heal us
BRAIN MAPPING
NANOMEDICINE
NERVE CELLS
DIGESTIVE SYSTEM
REGENERATION
DISCOVER SCIENCE SERIES
SECRETS OF THE HUMAN BODY

ORDER NOW!

DELIVERED DIRECT TO YOUR DOOR

Order online at **www.myfavouritemagazines.com**
or find us in your nearest supermarket, newsagent or bookstore!

Sponsored by newegg.com
TAKE IT FROM A GEEK.℠

THE BUILDS

BUDGET GAMER

INGREDIENTS

PART			PRICE
Case	Cougar QBX		$55
PSU	Corsair CS550M		$80
Mobo	ASRock H170M-ITX/ac		$90
CPU	Intel Core i5-6500		$205
GPU	PowerColor Radeon R9 380 4GB	**NEW**	$190
RAM	8GB (2x 4GB) G.Skill Aegis DDR4-2133	**NEW**	$29
SSD	240GB SanDisk Ultra II 2.5-inch SATA	**NEW**	$75
HDD	1TB Seagate Barracuda 7,200rpm 3.5-inch SATA		$57
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit		$16

Approximate Price: $797

WITH BIG CHANGES last month, we kept things a bit more conservative this time. First, the Sapphire Nitro R9 390 and ASRock H170M-ITX/ac both increased in price, so we wanted to find a place to cut. We found one in the memory department. Memory prices fluctuate, and we found an 8GB kit of G.Skill's Aegis for just under $30. The big change came to the SSD. The SanDisk Ultra II isn't as speedy as Samsung's 850 Evo, but it's still a decent SSD. And it's about $12 cheaper. When it comes down to it, few users will really push even a SATA SSD to its limit outside of installing your OS. If you want to cut the cost further, just about any SSD offers a performance jump over an HDD. While we've listed the PowerColor R9 380 for our GPU, you'll probably have better options by the time you read this. At the time of writing, AMD's Polaris-based cards hadn't been announced, but we were told to keep an eye out for the RX 480, rumoured to retail for $250.

MIDRANGE

INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Pro M		$75
PSU	EVGA SuperNOVA G2 650W 80 Plus Gold	**NEW**	$90
Mobo	Asus Z170-A		$155
CPU	Intel Core i5-6600K		$245
Cooler	Corsair H80i v2		$87
GPU	Nvidia GeForce GTX 1070	**NEW**	$379
RAM	16GB (2x 8GB) G.Skill Ripjaws 4 Series DDR4-2400	**NEW**	$60
SSD	250GB Samsung 850 EVO 2.5-inch SATA	**NEW**	$89
HDD	Western Digital Black Series 1TB 7,200rpm		$74
OS	Windows 10 (*Download*)		$110

Approximate Price: $1,364

THE NEW WAVE of GeForce GTX cards is here, and we just had to include the new GTX 1070 GPU. At the time of writing, the GTX 1070 hadn't been released, but the card's performance, coupled with its price, makes purchasing a GTX 980 silly. We're only able to list the MSRP for the reference design here, as we haven't had a chance to see what each individual vendor offers in terms of cooling. We can bet that MSI should offer its Gaming line, and EVGA will likely offer its ACX cooling designs. We went back to EVGA for our PSU, due to the seven-year warranty that the 650W SuperNOVA G2 offers. For memory, we went with G.Skill's Ripjaws 4 Series. RAM prices increased slightly, so we swapped out the Vengeance LPX sticks for G.Skill's kit, which comes with a CAS latency of 15, and kept the price at $60. Finally, we had to go with the 2.5-inch SATA Samsung 850 Evo drive. The M.2 850 Evo is around $160—nearly twice the price of the 2.5-inch version.

TURBO

AGAIN, WE SEE A BIG SHIFT IN THIS BUILD, thanks to Nvidia's monstrous new GeForce GTX 1080. Like the GTX 1070, we've been testing the card in-house, and you can find out what we think of the Founders Edition on page 74. We've listed Nvidia's MSRP for the card for reference, but you can bet that there will be an array of prices, due to cooling designs and availability. Needless to say, a single GTX 1080 leaves the GTX Titan X in the dust, for a price that competes with a single GTX 980 Ti. Like the midrange build, we fuddled with storage a little as well. Going from an SLI setup to a single GPU frees up a lot of resources, which we spent on upgrading the storage capabilities of this build. Gone are the spinning hard drives, and we got a pair of 1TB Samsung 850 Evo SSDs to take their place. Sure, this cuts storage in half, but the speed and reliability of the drives are much better than their platter-spinning cousins. Finally, we were able to find a 2,400MHz kit of G.Skill's Ripjaws V Series for just $110. We used those savings toward the 850 Evos, and still managed to come out $270 under our $3,000 budget.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART		PRICE
Case	Cooler Master MasterCase 5	$105
PSU	EVGA SuperNOVA G2 850W	$130
Mobo	MSI X99A SLI Plus	$230
CPU	Intel Core i7-5820K	$390
Cooler	Corsair H100i v2	$98
GPU	Nvidia GeForce GTX 1080 **NEW**	$599
RAM	32GB (4x 8GB) G.Skill Ripjaws V Series DDR4-2400 **NEW**	$110
SSD	512GB Samsung 950 Pro M.2 (NVMe)	$317
HDD	2x 1TB Samsung 850 Evo 2.5-inch SATA **NEW**	$640
OS	Windows 10 (*Download*)	$110

Approximate Price: $2,729

UPGRADE OF THE MONTH

GEFORCE GTX
GTX 1080

GEFORCE GTX 1080

The GTX 1080 is the new king of the video card world. Faster than a Titan X or a pair of 980s, the GTX 1080 is by far the best upgrade you should consider for a while. At $599, the card costs about the same as a GTX 980 Ti did (though the Founders Edition costs an extra $100). As much as we loved the 980 Ti and Maxwell, Pascal is burying its older sibling.

$599, www.nvidia.com

MAXIMUM PC (ISSN 1522-4279) is published 13 times a year, monthly plus Holiday issue following December issue, by Future US, Inc., One Lombard Street, Suite 200, San Francisco, CA 94111. Phone: (650) 872-1642. Fax: (650) 872-2207. Website: www.futureus.com. Periodicals postage paid in San Bruno, CA, and at additional mailing offices. Newsstand distribution is handled by Curtis Circulation Company. Basic subscription rates: one year (12 issues) US: $19.95; Canada: US$24.95; Foreign: US$34.95. Canadian and foreign orders must be prepaid. Canadian price includes postage and GST (GST #R128220688). PMA #40612608. Subscriptions do not include newsstand specials. POSTMASTER: Send changes of address to Maximum PC, PO Box 5852, Harlan, IA 51593-1352. Standard Mail enclosure in the following editions: None. Ride-Along enclosure in the following editions: None. Returns: IMEX Global Solutions, PO Box 25542, London, ON N6C 6B2, Canada. Future US, Inc. also publishes @Gamer, Mac|Life, The Official Xbox Magazine, and PC Gamer. Entire contents copyright 2016, Future US, Inc. All rights reserved. Reproduction in whole or in part is prohibited. Future US, Inc. is not affiliated with the companies or products covered in Maximum PC. Reproduction on the Internet of the articles and pictures in this magazine is illegal without the prior written consent of Maximum PC. Products named in the pages of Maximum PC are trademarks of their respective companies. PRODUCED IN THE UNITED STATES OF AMERICA.

ALIENWARE™

BOUNDARIES NOT INCLUDED.

Meet the dual graphics-ready Alienware Aurora, driven by 20 years of innovation and gamer feedback. Designed for virtual reality. Engineered with liquid cooling and tool-less access. Built to get you deeper in the game. With 6th generation Intel® Core™ Processors. Starting at $799.

START GAMING AT ALIENWARE.COM.

Intel Inside®.
Extraordinary
Performance Outside.

intel
CORE i7
inside™

Intel, the Intel Logo, Intel Inside, Intel Core, and Core Inside are trademarks of Intel Corporation in the U.S. and/or other countries.

WORLD'S MOST
ADVANCED PCs

DIGITALSTORM
GEFORCE GTX
GEFORCE GTX
GEFORCE GTX
CORSAIR HX1000i

DIGITALSTORM

Starting At:
$899

CUSTOMIZE NOW: WWW.DIGITALSTORM.COM
Digital Storm PCs featuring Intel® Core™ i7 processors.

The Digital Storm Logo, and 'World's Most Advanced PCs' are trademarks of Digital Storm.

Intel, the Intel Logo, Intel Inside, Intel Core, and Core Inside are trademarks of Intel Corporation in the U.S. and/or other countries.